Engineering Library

The Engineer.

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VOL. CXXXIX.—No. 3616] LONDON: FRIDAY EVENING, APRIL 17, 1925 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.

A Geared Shunting Locomotive.

The British Steam Railway Locomotive from 1825 to 1924—No. 16.

Institution of Naval Architects—No. III.

Shifting a Bridge in Vienna.

Water Power in Canada in 1924.

Government Tests of Agricultural Machinery.

The Platinum Boom in South Africa.

Mechanical Equivalent of Heat—Joule's First Experiments.

Increasing the Efficiency of the Screw Propeller.

PUBLIC NOTICES

Civil Engineer Required by the GOVERNMENT of UGANDA, for the PUBLIC WORKS DEPARTMENT, for a tour of 20 to 30 months' service. Salary £400, rising by annual increments of £20 to £500, and thence by annual increments of £25 to £600 a year, plus a temporary allowance of 20 per cent., at present authorised to the 30th June, when the matter of its continuance or otherwise will be considered. Free passages and liberal leave on full salary. Outfit allowance of £30 on first engagement. Candidates, aged 25 to 30, should have served articles with a civil engineer of standing and be an Associate Member of the Institution of Civil Engineers or hold equivalent professional qualifications. Should have had, as assistants, experience of building and road construction, including bridge work, also drainage and water supply, if possible. Training and experience in a Municipal Engineer's office would be suitable.—Apply at once by letter, stating age, qualifications, and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/13,487. 8929

Royal Corps of Naval CONSTRUCTORS.

A COMPETITIVE EXAMINATION for one or more POSTS as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the ROYAL NAVAL COLLEGE, GREENWICH, in June next.

The Regulations and full particulars of the salary, prospects of promotion, &c., may be obtained from the SECRETARY (C.E.), Admiralty, S.W. 1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience not later than 23rd April.

Preference will be given to ex-Service men.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.

In conjunction with the above Examination there will be a QUALIFYING EXAMINATION for the admission of PRIVATE STUDENTS of NAVAL ARCHITECTURE to the Royal Naval College, Greenwich. Applications for the Regulations, &c., should be made as in the case of the Examinations for the post of Probationary Assistant Constructors (see above).

Private Students are at present required to pay a fee of £30 a session whilst at the College, but this fee will probably be increased in the near future. 8875

G. R.

For Disposal by Tender,
40,000 TONS (EX GERMAN) FLOATING DOCK No. 23.

The ADMIRALTY have FOR DISPOSAL without restriction as to use abroad the above-mentioned DOCK, lying in sections at Chatham.

Brief particulars of the Dock are as follows :—

Lifting capacity	40,000 tons
Length overall	702ft. 9in.
Breadth	194ft.
Breadth to outside walls	183ft. 10in.
Width inside at top of walls	154ft. 2in.
Width inside at bottom of walls	147ft. 10in.
Minimum inside width (between fenders)	147ft. 2in.
Length of M.L. keel blocks	700ft.
Height of blocks	4ft. 3in.
Maximum draught of ship dockable, about	36ft.
Depth of water required at site to dock ship of 36ft. draught	63ft. 6in.
Time for lifting large ship	2-3 hours

The sections of the Dock are for sale as and where they lie and without any guarantees. Further particulars, Tender forms, conditions of sale, &c., together with an order to view, may be obtained upon application to the DIRECTOR of NAVY CONTRACTS, Admiralty, Room 62, Prince's House, Kingsway, London, W.C. 2.

Sealed Tenders are due at the Admiralty by Noon on Tuesday, the 12th May, 1925. 8921

G. R.

For Sale by Tender.
Closing 1st May, 1925, at 11 a.m.,
40 H.P. GAS PRODUCING PLANT,
at
THE GOVERNMENT INSTRUCTIONAL FACTORY, SARISBURY COURT, Near Fareham, Hants.

Forms of Tender can be obtained upon application to the CONTROLLER of SUPPLIES, Sales Section, H.M. Office of Works, King Charles-street, London, S.W. 8922

Bombay, Baroda, and Central INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 8th May, TENDERS for the SUPPLY of :—

1. LOCOMOTIVE BOILERS ;

and up to Noon on Wednesday, 6th May, TENDERS for :—

2. STEEL MATERIAL (CHANNELS, ANGLES, PLATES, &c.).
3. CRANK and STRAIGHT AXLES for LOCOS.
4. COPPER FIRE-BOX PLATES.
5. STEEL BOILER TUBES.
6. FENCING MATERIALS.
7. GALVANISED STEEL or IRONWORK.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20s. each for Nos. 1, 2, and 3, and 10s. each for Nos. 4, 5, 6, and 7 (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG, Secretary.

Offices : 91, Petty France, Westminster, S.W. 1. 15th April, 1925. 8930

PROPOSED BRIDGE OVER RIVER FORTH AT DRIP, STIRLING.

The County Councils of Stirling and Perth invite DESIGNS, along with TENDERS, for NEW BRIDGE, proposed to be erected over the River Forth at Drip, Stirling. Further details may be obtained from Mr. D. R. Cox, Road Surveyor, Stirling, and Mr. W. L. Gibson, Road Surveyor, Dunblane. Designs and Tenders should be lodged with the subscriber on or before Thursday 30th April next.

The County Councils do not bind themselves to accept any Design or Tender.

JAMES LEARMONTH, County Clerk.

County Buildings, Stirling, 26th March, 1925 8795

PUBLIC NOTICES

Crystal Palace School of Practical ENGINEERING.
Established 1872.

PRESIDENT : J. W. WILSON, M. Inst. C.E., M.I. Mech. E., F.S.I.

PRINCIPAL : MAURICE WILSON, M. Inst. C.E.

VICE-PRINCIPAL : F. C. P. LAWRENCE, M.S.E., A.M.I. Struct. E.

The NEW COURSE will COMMENCE on WEDNESDAY, APRIL 29th. New Students enter at the School on the previous morning. 8905

City and County of Bristol.
ELECTRICITY DEPARTMENT.
WATER-TUBE BOILERS.

The Electrical Committee are prepared to consider TENDERS for the SUPPLY, DELIVERY, and ERECTION of BOILER-HOUSE, 2 WATER-TUBE BOILERS, complete with all necessary Auxiliaries, Fittings and Accessories.

Copy of the specification and form of Tender may be obtained from the undersigned on payment of a deposit of Two Guineas, which amount will be returned upon the submission of a bona fide Tender. Duplicate copies of the specification will be charged for at the rate of 10s. 6d. per copy, which amount is not returnable.

Tenders, sealed and endorsed "Tender for Water-tube Boilers," must be returned in the special envelope issued with the specification, not later than 10 a.m. on Tuesday, 12th May, 1925.

The lowest or any Tender will not necessarily be accepted.

H. FARADAY PROCTOR, M. Inst. C.E., M.I.E.E., Chief Engineer and General Manager.

Electricity Offices, Colston-avenue, Bristol. 8939

Borough of Chatham.
INTERNAL SEWERS, CONTRACT No. 1.

The Corporation is prepared to receive TENDERS for the CONSTRUCTION of about—

330 Yards Lin., 18in. diam., IRON PIPE SEWERS.
1,927 Yards Lin., 18in. diam., STONEWARE PIPE SEWERS.
130 Yards Lin., 15in. diam., STONEWARE PIPE SEWERS.
2,340 Yards Lin., 12in. diam., STONEWARE PIPE SEWERS.
12,960 Yards Lin., 9in. diam., STONEWARE PIPE SEWERS.
10,140 Yards Lin., 7in. diam., STONEWARE PIPE SEWERS.

Together with Manholes and other Appurtenant Works in the High Level Area of the Borough of Chatham.

As the works the subject of this contract are works in respect of which grants are to be given expressly because of unemployment by the Unemployment Grants Committee, it is a condition of the grant that all contracts for or incidental to the works shall be placed in this country.

All goods and materials supplied under the contract shall be of British production and manufacture.

Plans may be seen and general conditions of contract, specification, quantities and form of Tender may be obtained at the office of the Engineers, Messrs. W. H. Radford and Son, Chartered Civil Engineers, Albion Chambers, King-street, Nottingham, and also at my office, as under, on deposit of Five Guineas (cheque), which will be returned on receipt of a bona fide Tender and the return of the quantities.

The lowest or any Tender will not necessarily be accepted.

Sealed Tenders are to be delivered to me at my office as under on or before April 27th, 1925, endorsed "Chatham Internal Sewers, No. 1."

By order, EDWARD B. LEE, Town Clerk.

Town Hall, Chatham, Kent, 27th March, 1925. 8796

PUBLIC NOTICES

Rochester and Chatham Joint SEWERAGE BOARD.
OUTFALL SEWER.
CONTRACT No. 2.

The Board is prepared to receive TENDERS for the CONSTRUCTION of about—

345 Yards Lin., 42in. diameter, CONCRETE SEWER CULVERT.
138 Yards Lin., 39in. diameter, CONCRETE SEWER CULVERT.
1176 Yards Lin., 36in. diameter, CONCRETE SEWER CULVERT.
1154 Yards Lin., 30in. diameter, CONCRETE SEWER CULVERT.

and 1136 Yards Lin. LAYING and JOINTING 30in. diameter CAST IRON PIPES, 2230 yards of these lengths being in tunnel, together with deep Manholes and other Appurtenant Works.

The works are part of the Board's scheme of sewerage, which is approved for grant by the Unemployment Grants Committee, and that Committee has laid down as a condition that all contracts for or incidental to the works are to be placed in this country.

The Board will require that all goods and materials supplied shall be of British production and manufacture.

Plans may be seen, and quantities and form of Tender, specification and conditions of contract obtained, at the office of the Engineers, Messrs. W. H. Radford and Son, Chartered Civil Engineers, Albion Chambers, King-street, Nottingham, and also at my office, as under, on deposit of Five Guineas (cheque), which will be returned on receipt of a bona fide Tender and the return of the quantities.

The lowest or any Tender will not necessarily be accepted.

Sealed Tenders to be delivered to me at my office, as under, on or before Thursday, the 30th April, 1925, endorsed "Contract No. 2, Joint Sewer."

By Order, EDWARD B. LEE, Clerk to the Board.

Town Hall, Chatham, Kent, 26th March, 1925. 8793

Rochester and Chatham Joint SEWERAGE BOARD.
OUTFALL SEWER—CONTRACT No. 3.
TO IRONFOUNDERS.

The Board is prepared to receive TENDERS direct from Ironfounders for the SUPPLY and DELIVERY at Chatham, Kent, of about 500 Tons of CAST IRON PIPES and SPECIAL CASTINGS.

The pipes and special castings will be mostly 30in. diameter, and small quantities of 24in., 18in., 12in., 9in., and 7in.; also a number of Manhole Covers, &c.

The pipes and castings are required in connection with the Board's scheme of sewerage, which is approved for grant by the Unemployment Grants Committee, and that Committee has laid down as a condition that all contracts for or incidental to the works are to be placed in this country.

The Board will require that all goods shall be of British production and manufacture.

Quantities and form of Tender, specification and conditions of contract may be obtained from the office of the Engineers, Messrs. W. H. Radford and Son, Chartered Civil Engineers, Albion Chambers, King street, Nottingham, on a deposit of Two Guineas (cheque), which sum will be returned on receipt of a bona fide Tender and the return of the quantities, &c.

The lowest or any Tender will not necessarily be accepted.

Sealed Tenders to be delivered to me at my office, as under, on or before Thursday, the 30th April, 1925, endorsed "Ironwork Contract."

By Order, EDWARD B. LEE, Clerk to the Board.

Town Hall, Chatham, Kent, 26th March, 1925 8794

PUBLIC NOTICES

Metropolitan Asylums Board
TO ENGINEERS.

The Board invite separate TENDERS for :—

(A) GENERAL ENGINEERING WORK, including Steam Plant, Steam and Condense Mains, Heating and H.W.S. Mains and Apparatus, Electric Motor Drives for Deep Well Engines and Laundry, &c.
(B) INSTALLATION of FOUR NEW LANCASHIRE STEAM BOILERS.
(C) INSTALLATION of NEW FUEL ECONOMISER.
(D) BUILDING BRICKWORK SETTINGS for Four Boilers and Fuel Economiser.
(E) INSTALLATION of NEW LAUNDRY MACHINERY and PLANT.
(F) INSTALLATION of ELECTRICAL GENERATING PLANT, MOTORS, and POWER WIRING at Leavesden Mental Hospital, King's Langley, Herts ; each

in accordance with the specification and drawings prepared by Mr. T. Cooper, M. Inst. C.E., M.I. Mech. E., Engineer-in-Chief. The specification, drawings, and forms of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after 10 a.m. on Wednesday, 15th April, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a bona fide Tender sent in accordance with the instructions on the form of Tender and after the specification and the drawings have been returned.

Tenders, addressed as noted on the form, must be delivered at the office of the Board not later than 2.30 p.m. on Wednesday, 20th May, 1925.

G. A. POWELL, Clerk to the Board. 8914

Bombay, Baroda and Central INDIA RAILWAY.
ASSISTANT ELECTRICAL ENGINEER.

The Directors are prepared to receive APPLICATIONS (by letter only) from properly qualified candidates for APPOINTMENT to the above POST.

Candidates must be not more than 30 years of age and must have had a good general and technical education and a thorough training in electrical engineering, workshops, and be experienced in electric traction, block instruments, and track circuits.

SALARY.—Rupees 450 or according to age and qualifications, rising by annual increments according to the Rules in force to Rs. 1100 per calendar month.

TERMS.—A three years' agreement in the first instance, first-class free passage to India and home again on satisfactory termination of services.

The selected candidate will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Applications, by letter only, stating age and giving a full record of education and candidates' career in chronological order (with dates), showing in detail where and how they have been employed from time to time, and the class of work employed upon, should be addressed to the undersigned not later than the 8th May, 1925.

S. G. S. YOUNG, Secretary.

Offices : The White Mansion, 91, Petty France, Westminster, S.W. 1. 9th April, 1925. 8920

Municipality of George Town, PENANG, STRAITS SETTLEMENTS.
ASSISTANT ENGINEER.
ADVERTISEMENT.

The Municipal Commissioners of George Town, Penang, REQUIRE an ASSISTANT ENGINEER, age 25 to 32, preferably unmarried, on a three years' agreement with possible extension. Applicants must have had a good technical education and a regular training as pupil and assistant in a Municipal or County Engineer's Office, with experience in municipal and general engineering work, including Roads, Buildings, Bridges, Sewerage and Conservancy details, and the control of workmen. Preference will be given to candidates who have a knowledge of the design of Sewage Works and who have passed the Testamur Examination of the Institution of Municipal and County Engineers.

Salary 5400 dollars for the first year, rising, if the officer remains in the service, by biennial increments of 300 dollars a year to a maximum of 9000 dollars per annum, paid monthly in dollars, the currency of the Colony, the value of the dollar being 2s. 4d. sterling. The pay of the appointment at this rate for the first year would be £630. An allowance for the maintenance of a motor car when on duty will be granted. Free passage will be provided, with half pay during the voyage out. The selected candidate must pass an approved medical examination.

Applications, stating whether married or single, age, birthplace, and giving details of education, training and experience generally, with particular reference to the items mentioned above, and copies (only) of testimonials, to be lodged with Messrs. PEIRCE and WILLIAMS, MM. Inst. C.E., 180, Hope-street, Glasgow, Agents for the Commissioners (who will give further particulars if requested), not later than Tuesday, 21st April, 1925. 8892

PUBLIC NOTICES (continued) Page 2.

SITUATIONS OPEN, Page 2.
SITUATIONS WANTED, Page 2.
PATENTS, Page 2.
PARTNERSHIPS, Page 2.
AGENCIES, Page 2.
MISCELLANEOUS, Page 2.
FOR SALE, Pages 2, 3, 4 and 94.
AUCTIONS, Page 94.
BUSINESSES and PREMISES (For Sale, etc.), Page 94.
MACHINERY, &c., WANTED, Page 2.
WORK WANTED, Page 4.

For Advertisement Rates see Page 437, Col. 1.

INDEX TO ADVERTISEMENTS, Page 93.

PUBLIC NOTICES

County of London.

HOUSING DEVELOPMENT SCHEMES.
APPOINTMENT OF AN ASSISTANT TO ADMINISTRATOR.

The London County Council invites APPLICATIONS for the POSITION of an ASSISTANT to the ADMINISTRATOR of HOUSING DEVELOPMENT SCHEMES. The appointment will be a temporary one. The person selected will be required to act as an Assistant to the Administrator in the control and supervision of the large contracts of housing development schemes entered into by the Council. Candidates should have been trained either as civil engineers or architects, and have had considerable experience in the conduct of large construction works. Experience as a resident engineer or as an architect with outdoor experience on large construction works is required, and commercial knowledge gained on the staff of a large contractor would be a qualification. Preference will be given to candidates who have served or attempted to serve with His Majesty's Forces. Applicants who did not so serve must be naturalborn British subjects. The salary offered is at the inclusive rate of £750 a year. Application forms can be obtained from the Administrator of Housing Development Schemes, the Old County Hall, Springgardens, S.W. 1, to whom they must be returned not later than 11 a.m. on Friday, 24th April, 1925. Stamped foolscap envelope necessary. All communications must be marked "Assistant to Administrator." Canvassing disqualifies.

MONTAGU H. COX,
Clerk of the London County Council.
8915

SITUATIONS OPEN

WANTED, an Energetic Up-to-date ASSISTANT for WORKS MANAGER. Must be good disciplinarian, familiar with latest and best machine shop practice, and able to reduce costs of manufacture. Write, stating experience and salary expected. Good opening for right man.—Address, 8899, The Engineer Office. 8899 A

WANTED, ASSISTANT CIVIL ENGINEER for contract in France, speaking and writing French fluently.—State qualifications, experience and salary, H. T. JENKINS and SON, Ltd., Torquay. 8813 A

WANTED for Natal, as ASSISTANT FACTORY MANAGER, first-class ENGINEER, with good experience of Distillation and Evaporating Process. Salary £600 per annum. Appointment offers opportunity of advancement.—Write, "G. E.," c/o J. W. Vickers and Co., Ltd., 5, Nicholas-lane, E.C. 4. 8904 A

WANTED for Tea Estate in India, ASSISTANT; must be fully qualified engineer, knowledge of Oil Engines essential.—Write, Box N. C., c/o Davies and Co., 95, Bishopsgate, E.C. 2. 8911 A

WANTED, YOUNG CONTRACTORS' ENGINEER, for work near London. Must have had experience in Setting Out, Levelling and General Contractors' Work.—Write, Box 744, c/o Brown's, 39, Tothill-street, Westminster. 8912 A

A FIRM Specialising in Material Handling Plants are DESIROUS of SECURING the SERVICES of a first-class ENGINEER as HEAD DRAUGHTSMAN, capable of thoroughly controlling a large staff, passing work through correctly and expeditiously. Must be fully conversant with all details of manufacture and of office routine. Applications, treated confidentially, stating age, experience, and salary required, together with testimonials.—Address, 8913, The Engineer Office, 8913 A

APPRENTICES.—Well-known GENERAL ENGINEERING COMPANY in East Anglia has OPENING for a few smart well-educated YOUTHS as APPRENTICES. The period of training is apportioned to the various workshops and drawing-office. Graduated scale of wages. Moderate premium.—Address, 8924, The Engineer Office. 8924 A

ASSISTANT LOCOMOTIVE SUPERINTENDENT REQUIRED for South American Railway. Able to speak Spanish. £500/600 per annum.—Write, "E. L.," care of J. W. Vickers and Co., Ltd., 5, Nicholas-lane, E.C. 4 8948 A

ENGINEER (Outside Structural Supervisor) REQUIRED, capable organising rapid erection of large contract. State age, experience, and salary.—Address, 8867, The Engineer Office. 8867 A

INDIA.—Experienced PLATER for Bridge and Girder Shops REQUIRED. Must be well up in Jig and Template Work and have had several years' experience with first-class firms with modern methods of production and conversant with standard of work required by the Indian State Railways. Age 23-28 years; unmarried man preferred.—Write, giving full details of experience and copies of testimonials, to "Z. C. 388," c/o Deacon's Advertisement Agency, Leadenhall-street, London, E.C. 3. 8931 A

MESSRS. RAGOSINE and CO., Lubricating Oil Merchants, have a VACANCY for an additional qualified ENGINEER-SALESMAN. Must have a practical knowledge of Diesel Engines, Turbines, &c.—Apply, 161, Bow-road, E. 3. P500 A

REINFORCED CONCRETE.—TWO Competent SPECIALIST DESIGNERS REQUIRED in the provinces, with experience in the design of all types of Concrete Structures.—Address in confidence, stating age, salary required, and giving a brief summary of experience, 8932, The Engineer Office. 8932 A

REQUIRED, TRUE-TO-SCALE PRINTER, fully experienced, to take full control of small Room. Particulars and credentials.—Address, P509, The Engineer Office. P509 A

RESIDENT ENGINEER REQUIRED for New Sea Defence Works and Buildings. Must have had similar experience and possess sound knowledge of handling and working of large plant; competent to set out works, take levels, make surveys, supervise contractors' work, check quantities, make detail drawings, prepare specifications, and supervise and control labour. Thorough understanding of good work essential. Salary £7 7s. per week. State age, qualifications, and experience, with testimonials.—Address, 8933, The Engineer Office. 8933 A

R. Y. PICKERING and CO., Ltd., Railway Carriage and Wagon Builders, Wishaw, near Glasgow, have VACANCY for a WORKS MANAGER of sound technical, engineering and drawing-office experience, fully conversant with the manufacture of Railway Carriages and Wagons in all its branches, good organiser, able to control labour.—Apply, stating age, qualifications, salary required, when at liberty, and forward copies of recent testimonials, to JOHN ALSTON, Esq., Municipal Buildings, Coatbridge, Lanarkshire. 8942 A

SHIPYARD and ENGINEERING WORKS MANAGER REQUIRED for abroad (Servia), to take full technical charge of small composite undertaking capable of considerable development. Must be a trained practical man, capable of conducting and directing Ship Repair and Construction, Mechanical Engineering, Foundry, and kindred work in all its details. A good organiser and energetic. A knowledge of German is essential.
Address, giving full resume of training and experience, salary required, &c., P487, The Engineer Office. P487 A

WANTED for Aircraft Work, by S. E. SAUNDERS, Ltd., at Cowes, AERONAUTICAL or First-class LIGHT MECHANICAL DRAUGHTSMEN.—Apply, giving full particulars of experience and salary anticipated. Vacancies exist for 3 or 4 good men. 8863 A

WANTED, Fully Experienced DRAUGHTSMAN, accustomed to Gasworks and Chemical By-product Plant appertaining to the gas industry. Must be familiar with the designing of Condensers, Mechanical Gas Washer Scrubbers, Purifiers, &c. State age, experience, and when at liberty.—Address, 8910, The Engineer Office. 8910 A

SITUATIONS OPEN (continued)

WANTED, SENIOR DRAUGHTSMAN, with Experience of modern High-lift Centrifugal Pump requirements; must be practical and capable of laying out new designs.—State experience, age, and salary required to W. H. ALLEN SONS and CO., Ltd., Bedford. 8909 A

A LEADING FIRM of BANKERS' ENGINEERS REQUIRE the SERVICES of TWO Competent DRAUGHTSMEN, one experienced in Steel Office Furniture and the other in Reinforced Concrete. Give full particulars of experience, age and salary expected. —Address, 8881, The Engineer Office. 8881 A

ASSISTANT MECH. ENGINEER and DRAUGHTSMAN WANTED by London Engineers. Applicants, who should be well educated young men, must have experience in application of Centrifugal Fans and modern Boiler-house Arrangements and have a thorough knowledge of French.—Address, P499, The Engineer Office. P499 A

DRAUGHTSMEN.—BEFORE NEGOTIATING with Government Departments in connection with any post, PLEASE COMMUNICATE with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 98, St. George's-square, London, S.W. 1. 8768 A

DRAUGHTSMEN WANTED by Firm of Westminster Engineers. Must have thorough knowledge and experience of works in connection with Dock, Harbour and large Public Works Contracts.—Apply, giving full particulars of age, experience, and salary required, to Box 547, c/o Brown's, Tothill-street, Westminster, S.W. 1. 8814 A

DRAUGHTSMAN WANTED by Scottish Engineering Firm, with first-class experience in Mechanical Handling Plants for Coal and other Materials.—Address, stating age, experience, and salary required, P490, The Engineer Office, P490 A

DRAUGHTSMAN, with All-round Experience of Construction of Water-wheel Alternators, REQUIRED by Old-established Firm.—Address, with full particulars of experience and salary required, to 8820, The Engineer Office. 8820 A

EXPERIENCED DRAUGHTSMAN for Dust Removal Schemes and preferably with knowledge of Fan application.—Age, salary, and experience to Box 313, c/o Mather and Crowther, Ltd., 10, New Bridge-street, E.C. 4. 8938 A

EXPERIENCED DRAUGHTSMAN REQUIRED for temporary position, accustomed to the designing of Girder Work and other Constructional Work. Calculations of Stresses, &c.—Apply by letter to A. NEWLANDS, Esq., Divisional Engineer's Office, L.M. and S. Railway, Crewe, stating age, experience, and salary required. 8926 A

HEAD DRAUGHTSMAN for Structural Works, Glasgow district; must have sound theoretical and practical experience; age between 30 and 40; salary about £500 or over, according to qualifications. —Address, with full particulars, P442, The Engineer Office. P442 A

LARGE FIRM of GASWORKS PLANT MANUFACTURERS REQUIRE the SERVICES of TWO experienced and responsible DRAUGHTSMEN, used to Gasworks and Chemical Plant. Full details of experience, connection, salary required, &c.—Address, 8897, The Engineer Office. 8897 A

MECHANICAL and GENERAL ENGINEERING DRAUGHTSMAN REQUIRED, to Prepare Detail Drawings and Schemes in drawing-office of large manufacturing works in the Midlands. The following training is essential:—At least two years day student in recognised college or university diploma or engineering degree, and three years in workshop of well-known firm of general engineers. At least three years' drawing-office experience.—Address in confidence, stating age, training, experience, salary required, and when at liberty, 8856, The Engineer Office. 8856 A

REQUIRED (London), DRAUGHTSMAN, Experienced Water-tube Boilers and Boiler-house layout. State experience, age, and salary required.—Address, P466, The Engineer Office. P466 A

WORKS FOREMAN REQUIRED, East Midlands, with Pumping Machinery experience, used to accurate heavy work with general purpose machines, and capable organiser. State experience, salary, and when disengaged.—Address, 8900, The Engineer Office. 8900 A

SITUATIONS WANTED

A. M.I.C.E. (34), Locomotive, Mechanical, Steam, works and D.O. experience, experienced in control of large staffs, keen economist, some commercial experience, DESIRES POST as ASSISTANT MANAGER or other progressive post. Moderate salary.—Address, 8945, The Engineer Office. 8945 B

CHARTERED ENGINEER and ECONOMY SPECIALIST, resident Lancashire, is AVAILABLE in an Advisory Capacity, mechanical and civil, or for inspection work, or would REPRESENT a reputable FIRM.—Address, 8946, The Engineer Office. 8946 B

CIVIL ENGINEER (25), B.Sc. (Edinburgh), A.M.I.C.E., 4½ years' experience irrigation works in East, SEEKS POSITION at home or abroad. War service and highest references.—Address, P480, The Engineer Office. P480 B

ENGINEER, Aged 27, Recently Returned from the East, technical education and apprenticeship in marine repair work, with D.O., sea-going and oilfield experience, SEEKS responsible or administrative POST. Would accept moderate salary for post where skill and responsibility are required.—Address, P493, The Engineer Office. P493 B

ENGINEER and DESIGNER, with Wide Experience in concrete and tar-macadam roadmaking plant, mechanical and structural work, also control of D.O. staff, DESIRES similar POST.—Address, P496, The Engineer Office. P496 B

ENGINEER DESIGNER (29). Production and special machinery, 12 years' exp., last four in U.S.A., expert theory and practice, SEEKS POSITION. Manager or similar capacity, anywhere.—ENGINEER, 4, South View, Crosshills, Yorks. P489 B

ENG. LABORATORY ASSISTANT SEEKS CHANGE in Drawing-office or Laboratory. Good education and 6 years' experience. A.M.J.I.E.—W. F. JENNER, 174, Twickenham-road, Leytonstone. P491 B

ENGINEER (28), Sound Pub. School and Tech. educ., 10½ yrs. fit. and turn. exp., SEEKS further EXP., viz.:—D.O., commercial works, Ex. refs., mod. salary.—Address, P504, The Engineer Office. P504 B

ENGINEER (30) SEEKS Progressive BERTH; 15 years' practical experience, home and abroad; steam and gas engines, boilers, pumps, maintenance. Good technical knowledge. Would invest small amount.—A. D., 44, Cranfield-road, London, S.E. 4. P507 B

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For continuation of For Sale Advertisements see page 3.

A Seven-Day Journal

The Australian Cruisers.

IT has now been officially announced in this country that John Brown and Co., Ltd., of Clydebank and Sheffield, have received through the High Commissioner for Australia the order for the construction of the hulls and machinery of the two cruisers for the Royal Australian Navy. The order, which we understand has been placed subject to agreement upon certain details in the tender, was referred to in a Journal note of March 27th. In a leading article published in our issue of the 3rd inst. we reviewed the position of Australian naval defence in the light of this important contract, but at that time we could only speak of the new ships in a guarded way, for the news that they had been ordered was not then definitely confirmed. John Brown and Co., Ltd., are to be congratulated on receiving a valuable naval contract, the good effect of which will be felt in Clydebank and other industrial centres.

Small Arms Manufacture.

SPEAKING at the annual meeting last week of the Birmingham Small Arms Company, Ltd., the chairman of directors, Sir Hallewell Rogers, remarked that while the company's trade in sporting arms was as good as could be expected under present conditions, the business done in arms for military purposes had practically ceased to exist. The company, he continued, could not export military equipment to foreign countries without an official permit. It was obvious, he held, that if the company was not permitted to supply the requirements of foreign Governments, such Governments would obtain the arms they required from other countries. The company's capacity to manufacture small arms for abroad would undoubtedly be useful to the British Government in time of need. The directors, however, considered that the time had come when they should contemplate definitely and once and for all diverting the company's capacity for the production of military small arms into other channels which would provide more regular employment. Dealing with the company's activities as a whole, he stated that the trade in motor cars and motor cycles continued to provide the bulk of the profits, and that the value of the company's export business as a whole had steadily increased during the past three years. He ended on the optimistic note that slowly but surely the evil effects of the bad times through which the country had been passing were being shaken off.

Domestic Electricity Supplies and Methods of Charge.

UNDER the provisions of Sec. 4 of the Electricity (Supply) Act, 1919, the Electricity Commissioners have appointed an Advisory Committee to investigate and report on certain matters relating to domestic supplies and methods of charge. The questions to be dealt with are: (*a*) What steps are being taken by authorised undertakers to encourage and extend the use of electricity for domestic purposes, and what further steps could be taken to bring about an increased consumption of electricity for these purposes? (*b*) What methods of charge for domestic supplies could be authorised, as standard methods, subject to the fixing of an appropriate quantum in individual cases, in lieu of charging by the actual amount of energy supplied or by the electrical quantity contained in the supply? and (*c*) What legislative powers, if any, beyond those already conferred by the Electricity (Supply) Acts, would be necessary to give effect to any recommendations made in respect of questions (*a*) and (*b*). Mr. C. E. Allan has been appointed secretary to the Committee.

The Largest Aircraft Carrier.

THE United States aircraft carrier Saratoga, which was launched on the 7th inst. at the Camden, N.J., yard of the New York Shipbuilding Company, was laid down in August, 1920. This vessel was designed originally as a battle-cruiser, and she and five sister ships were listed for scrapping under the Washington Treaty. Eventually, however, it was decided to convert two of the vessels, Saratoga and Lexington, into aircraft carriers, on a reduced displacement of 33,000 tons, as compared with the original figure of 43,500 tons. No change appears to have been made in the propelling machinery, which consists of turbines with electrical transmission, designed for an output of 180,000 horse-power and a speed of 33¼ knots. A higher speed is, however, anticipated, owing to the considerable reduction in the weight of the ship. It is of interest to note that the machinery is to develop 36,000 horse-power more than that of H.M.S. Hood, hitherto the most powerfully engined vessel afloat. The length of the Saratoga's hull is 874ft. overall, the beam is something over 104ft., and the mean draught 22ft. From end to end the flight deck has a total length of 888ft. The uptakes from all the sixteen White-Forster boilers lead into a single very large funnel, which, with the superstructure and tripod foremast, is placed at the starboard side of the centre line, leaving the major area of the flight deck clear of obstacles. Provision is made for storing and handling seventy-two aircraft. Unlike most of the existing carriers, the Saratoga is fitted with a thick armour belt, in addition to horizontal armour. She will mount an armament of eight 8in. guns, twelve 5in. anti-aircraft pieces, and six torpedo tubes. Her cost is estimated at £9,000,000. She is the largest ship of any description which has, so far, been built in the United States.

The New Wireless Bill.

REPRESENTATIVES of the Radio Association, the Institution of Electrical Engineers, the Royal Society and other bodies met a few days ago at the General Post Office to consider the clauses of the Wireless Bill dealing with the transmission of energy. The subject under discussion was the question of how etheric waves should be defined. The question has been made somewhat complex by reason of the fact that certain medical and scientific instruments produce ether waves, and if these devices are to be included in the definition doctors using electrical apparatus would have to take out wireless licences.

The Metropolitan-Vickers Electrical Company's Annual Meeting.

AT the twenty-fifth annual general meeting of the Metropolitan-Vickers Electrical Company the chairman of the company, Major General Sir Philip A. M. Nash, said that the year 1924 witnessed a record output from the works, even in comparison with the war years, when a large tonnage of munitions was turned out. The volume of the export business for the year 1924 showed an increase of 43.8 per cent. over 1923. At present about 50 per cent. of the work passing through the company's shops was for export; in other words, every other workman was deriving his living from work obtained outside Great Britain. The difficulty of obtaining export work, however, was not diminishing. World competition was as severe as ever it was, and it might become worse. The British manufacturer's principal handicap, Sir Philip continued, was high price, and if faced with an increased cost of production his chances of attracting work to this country would be less than ever. Unless the cost of British products could be kept down the present volume of export work would become less and the workpeople of the country would suffer. In dealing with the activities of the "supply" section of the company, which is devoted to domestic appliances, &c., Sir Philip referred to the lack of co-operation between the manufacturers and the electricity supply authorities. In that respect, he said, the United States of America were far ahead of us.

An Interchange of Locomotives.

WITH a view to obtaining additional data regarding the running performance of modern express engines, an interchange of locomotives has been arranged by the chief mechanical engineers of the Great Western and the London and North-Eastern Railway companies. A four-cylinder Great Western engine of the "Caerphilly Castle" class, designed by Mr. C. B. Collett and described in THE ENGINEER of August 24th, 1923, will be lent to the London and North-Eastern Railway in exchange for one of Mr. H. N. Gresley's three-cylinder "Pacific" type passenger express engines. This locomotive was described in our issue of April 14th, 1922, and on April 27th, 1923, details of its construction were given. Each engine will be manned by a driver and fireman of its own company. It is intended to attach the Great Western locomotive to the 10 a.m. Flying Scotchman express from King's Cross, while the "Pacific" engine will draw the famous Cornish Riviera express, which leaves Paddington at 10.30 a.m. for Penzance with a non-stop run of 227 miles to Plymouth. Preliminary runs are to be made next week, but the real trials during which the visiting locomotives will be run on the trains named on alternate days will take place during the week beginning April 27th. The experiment promises to be an interesting one, and valuable comparative running data should be obtained from it, but it must not be forgotten that Mr. Collett's engine was designed for a coal much better than that used in Mr. Gresley's engine and that its grate area is much less.

London Traffic Congestion.

THE discomfort and delay which Londoners have frequently suffered as a result of the execution of road repairs in an unco-ordinated manner should be largely avoided this summer by the action which the Minister of Transport has just taken under the London Traffic Act, 1924. A lengthy list of road repairs, notice of the undertaking of which has been received, has been compiled, and against each dates have been inserted for the beginning and completion of the operations. The scheme is binding on all the road authorities concerned. In selecting the dates for the execution of the works the Minister has sought to avoid the closing or partial closing of any thoroughfare during a period when public engagements will call for its extensive use, or when an adjoining thoroughfare will also be under repair. On the constructive side it is proposed by the London Traffic Advisory Committee that permanent relief of congestion should be sought by, among other expedients, the provision of vehicular traffic subways at important crossing points in the West End. These subways, it is suggested, would meet the objections raised against overhead bridges of the kind proposed some time ago by Sir Alfred Yarrow. It is stated that negotiations are already proceeding for the construction of one of these subways. Another problem connected with London's traffic congestion is the provision of suitable and adequate parking spaces for cars. To provide a solution the Automobile Association has produced a scheme for the construction of a large subterranean parking hall beneath Leicester-square.

Seaplanes in Central Africa.

SINCE last November negotiations have been proceeding between the Governments of Kenya, Uganda, and the Sudan and the Blackburn Aeroplane and Motor Company, Ltd., of Leeds, regarding the establishment of an air service between Kisuma, on Lake Victoria Nyanza, and Khartoum. These negotiations have, it is announced, now reached a satisfactory stage in so far that the Governments named have agreed to assist in carrying out a preliminary survey of a route for the proposed service. The distance covered by the route will be upwards of 1200 miles. Although the survey has not yet been completed, the service will probably follow the course of the Nile, and with that object in view seaplanes will be employed. The company's representative, Captain Gladstone, is at present making a special study of the proposed route, and the design of the machines to be used will be based upon his report as to the conditions to be met.

A New Harbour for Madeira.

EARLY developments are expected to take place in connection with the construction of the proposed harbour breakwater at Funchal, Madeira. Plans, we understand, have been prepared by Sir Murdoch Macdonald and Partners, of Westminster, and a Harbour Board has been formed in Madeira to finance and administer the undertaking. The harbour breakwater contemplated will be about 3200ft. in length with a maximum depth of 54ft. At low tide there will be a depth of 25ft. of water at the quayside. At present it is necessary for passenger and cargo vessels to anchor some two miles from the shore, but when completed the new harbour will provide ample accommodation for the largest vessels which call at the port, and it will also give the bay protection from the heavy winter seas of the Atlantic. A considerable amount of deep dredging will have to be done, and it is estimated that the total cost of the work will be between £1,500,000 and £2,000,000, a large portion of which sum will be spent on materials and plant in this country. It is anticipated that it may be possible to begin the work in a few months' time and that about five years will be occupied in its execution.

Aeroplane Control at Low Speeds.

ON Wednesday, demonstrations were given at Croydon with two aeroplanes—one a Fokker 450 horse-power cantilever monoplane and the other an Avro 100 horse-power biplane fitted with Handley Page slotted wings—designed to show what can now be done in the way of controlling aeroplanes at speeds less than that corresponding to the "stalling" condition. The Fokker machine was equipped with enlarged wings and lateral control surfaces, and with the pilot and nine passengers on board it was shown to be able to retain an even keel after the stalling condition had been reached, instead of diving in a spin, as is usual with many aeroplanes when stalled. The performance of the Avro machine was very noteworthy. Although its normal stalling speed is 38 miles an hour, its pilot was able to exercise complete control over it at speeds as low as 27 miles an hour.

The Liner Montlaurier.

FEW vessels, we imagine, have sustained such a consecutive run of mishaps as the Canadian Pacific liner Montlaurier, which was badly damaged by fire on Wednesday whilst in dry dock at Cammell Laird's yard, Birkenhead. On a voyage from Liverpool to New Brunswick in February the steering gear of the ship broke down, and it was with difficulty that Queenstown Harbour was eventually reached. While entering the harbour the Montlaurier ran aground, and after her passengers and cargo were transferred, she was assisted by a tug to Liverpool for docking and repairs. Since March 6th she has been in dry dock at Birkenhead, and the repairs having been completed, it was anticipated that she would be towed on Thursday to the West Basin to undergo preparations for her scheduled sailing from Glasgow on April 24th. The fire broke out at 7 a.m. in the third-class quarters forward, and it was with great difficulty that with the help of four fire brigades the flames were prevented from spreading aft and totally destroying the ship's accommodation. The fire was under control by one o'clock the same day. The Montlaurier is a 17,000-ton ship, and was built in Germany in 1908.

The British Steam Railway Locomotive from 1825 to 1924.

By E. L. AHRONS, M.I. Mech. E.

No. XVI.*

PERIOD 1855–1859.

The principal events of this period were the first introduction of the four-wheels coupled *express* engine, the success of which at that time was very doubtful, the more extended use of the bogie, and, finally, the victory, after long-continued experiments, of coal over coke for locomotive fuel. The subject of coal burning will be dealt with in a subsequent section.

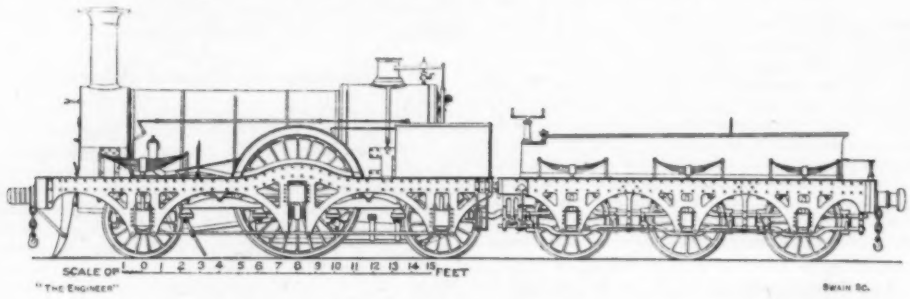


FIG. 110—G.W. LOCOMOTIVE, 1855

2–2–2 *Express Engines: Inside Cylinders.*—A few of the more interesting classes may be briefly mentioned. The first standard gauge G.W.R. engines are shown in Fig. 110. They were built to D. Gooch's designs by Beyer, Peacock and Co., in 1855, and were the first locomotives constructed by this firm, which had just been founded in 1854. Their chief characteristics were the slotted out sandwich frames, and the application of compensating levers between the three axles. The arrangement of india-rubber pads on the spring pillars beneath the levers may be noted. Such pads were always a feature of G.W.R. locomotive practice until recently, as also were the long "open-plated" springs, which for the leading wheels of these engines were 4ft. 6in. long. The writer can bear testimony to the very easy and smooth riding of the engines fitted with these springs. When the above locomotives were reconstructed, the compensating levers were discarded. As originally built, the engines had 15½in. by 22in. cylinders, 6ft. 6in. driving and 4ft. carrying wheels; wheel base, 15ft. 6in. The boiler, 4ft. diameter, contained 193 2in. tubes, and had a total heating surface of 1112 square feet, of which the fire-box provided 109.8 square feet. The grate area was only 13.6 square feet. The boiler

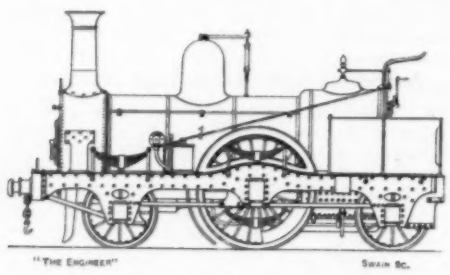


FIG. 111—MIDLAND LOCOMOTIVE NO. 1, 1850

was riveted to the motion plate, but was provided with an expansion bracket at the fire-box end.

The standard Midland express engine, as built at Derby, 1856 to 1861, is shown in Fig. 111. It had 6ft. 8in. driving wheels, 15ft. 6in. wheel base equally divided, and 16in. by 22in. cylinders. Although Matthew Kirtley from 1852 onwards always used outside plate frames and flush fire-box casings for his goods engines, the passenger engines had sandwich frames and raised fire-box casings. The driving horns, as in Sharp's engines, were very short, but unlike Sharp's were united by stiff rectangular tie bars. The weight in working order varied from 28 to 28½ tons.

A different design by Beyer, Peacock and Co., 1856, for the Edinburgh and Glasgow Railway—Fig. 113—is characteristic of this firm, and shows the simplicity of design and neatness of appearance which the British locomotive was now assuming. Both inside and outside frames were solid and extended from front to back buffer beams, but the driving axle had inside bearings only. The fire-box was raised slightly above the barrel, but this detail was hidden by the flush clothing. The boiler, like that of Gooch's engine, was domeless, with perforated steam collecting pipe and regulator in the smoke-box. Cylinders, 16in. by 20in.; driving wheels, 6ft. 6in.; carrying wheels, 3ft. 6in.; wheel base, 14ft. 6in., equally divided. The boiler, 3ft. 11in. diameter inside the smallest ring, was pitched 6ft. 7½in. centre above rails; the 171 2in. tubes had ¼in. clearance between them to allow sufficient water room. The blast pipe had a 4½in. orifice, situated just above the top row of tubes, a position decided upon as a result of Peacock's experiments on the Manchester, Sheffield and Lincolnshire Railway, described fully by D. K. Clark.[1] The main crank axle journals were 6½in. diameter by 7¾in. long. These engines, which were re-boilered by D. Drummond in 1880 on the N.B.R. had a life of more than fifty years.

2–2–2 *Engines: Outside Cylinders.*—Joseph Beattie's engines of the "Canute" class—Fig. 112—were built at Nine Elms in 1855–6, and were fitted with his patent feed-water heating apparatus, with condenser in front of the chimney, and also with a combustion chamber between the fire-box and boiler barrel. The leading wheels had inside main bearings, but were also provided with small outside steadying bearings, which carried only a very small proportion of the weight. These outside axle-boxes were without guides, and the underhung springs took their load from the bottom slide bars. This arrangement was peculiar to all the Beattie passenger engines until 1875. The trailing wheels had ordinary outside bearings only, so that the journals were removed from the influence of the heat of the fire-box. The valves were above the cylinders and actuated by rocking shafts and inside Stephenson gear. The cylinders were 15in. by 21in.; driving wheels, 6ft. 6in.; leading wheels, 3ft. 6in.; trailing wheels, 3ft. 7½in. diameter; the boiler barrel contained 373 tubes, 1¼in. outside diameter, 6ft. long. The back portion of the barrel contained the flat-roofed combustion chamber, 4ft. 2in. long by 3ft. 6in. diameter; heating surface, tubes 625 square feet, combustion chamber 37 square feet, fire-box 107 square feet, total 769 square feet; fire-grate in two parts, 16 square feet total area. Of the total weight of 28 tons 9 cwt., only 9 tons 9 cwt. were normally available for adhesion. This inefficient weight distribution, caused partly by the weight of the condensing apparatus, both within and without the smoke-box, and partly by the necessity of placing the leading wheels somewhat far back to clear the outside cylinders, was

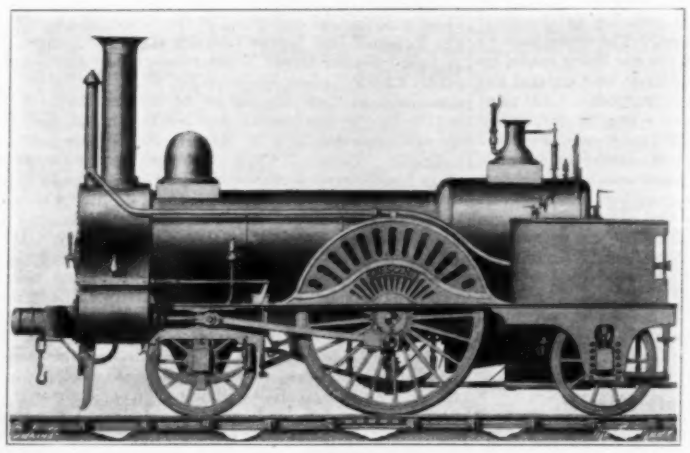


FIG. 112—L. AND S.W. LOCOMOTIVE, 1855

possibly the reason for the abandonment of single-driver express engines by the L. and S.W.R. in favour of four coupled engines as early as 1859, after which year no more "singles" were built. This railway was the first to discard the "single" engine.

That Beattie considered that the weight on the drivers might require modification seems to be shown by the peculiar arrangement of worm and worm wheel interposed between the spring buckle and the axle-box keep.

Another peculiarity was the bent pipe shown underneath the smoke-box, which terminated in a large bell-mouthed end open to the front. The other end of the pipe terminated inside the smoke-box in the blast orifice, at the junction of the breeches exhaust pipes from the two cylinders. The idea appears to have been to assist the blast by means of an additional air draught through the orifice, thus making up for the exhaust steam taken for feed-water heating.[2]

One other engine of the outside cylinder type—Fig. 114—is of interest in that it was the first express engine designed by Patrick Stirling, then locomotive superintendent of the Glasgow and South-Western Railway. It was also the first engine to be built at this company's works at Kilmarnock in 1857. This type, with outside cylinders and inside bearings throughout, appears to owe its origin partly to the old engines—Fig. 35 *ante*—built in 1839 by Messrs. Stirling, of Dundee, and partly to P. Robertson, Mr. Stirling's predecessor on the G. and S.W.R. In the design we see the genesis of the famous 8ft. singles of a later Great Northern period, but in 1857 Stirling used a domed boiler, and it was not until 1860 that he built several similar engines without domes. Until 1865 the engine illustrated was the standard express locomotive on the G. and S.W.R. The cylinders were 16in. by 21in., and the driving wheels 6ft. 6in. diameter.

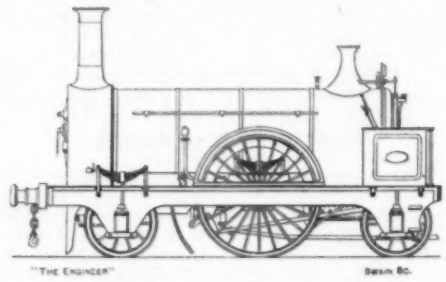


FIG. 113—EDINBURGH AND GLASGOW ENGINE, 1856

Four-wheels Coupled Express Engines.—Although four-coupled engines had been in service for many years, their use had been confined to ordinary passenger and goods trains, and their wheels did not exceed 6ft. in diameter. In the engines about to be described the diameter of the wheels was increased to 6ft. 6in. and 7ft.

For the 7ft. gauge of the Great Western Railway D. Gooch designed the engines—illustrated in The Engineer of December 16th, 1910—ten of which were built in 1855 by Messrs. Stephenson. They were not intended to replace the 7ft. and 8ft. singles on the main line between London and Bristol, but were built to run the faster trains between Swindon and South Wales, where on some sections, especially between Swindon and Gloucester, the gradients are severe. The speeds of these trains were only moderate. Although the wheel arrangement was of the 4–4–0 type, there was no leading bogie, and, like the 8ft. single engines, the two pairs of leading wheels were rigid. The frames were of the sandwich type, but placed inside the wheels. The cylinders were 17in. by 24in. and the driving wheels, were 7ft. diameter, the first of this size to be used for a coupled engine. The carrying wheels were 4ft. 3in. The total wheel base, which was rigid, was 17ft. 11½in., the coupled wheel base being 7ft. 5in.; boiler, 4ft. 6in. diameter; heating surface of tubes, 1444.2 square feet; of fire-box, 129.8 square feet; total, 1574 square feet; grate, 19.2 square feet; total weight in working order, 36 tons 13 cwt. 2 qr., of which 21 tons 12 cwt. were available for adhesion.

It cannot be said that these engines were a success for express work, though they proved fairly useful for excursion and other heavy passenger service. They were never rebuilt; two were broken up in 1872, and the others in 1876, their average mileage amounting to 497,200. The type was not perpetuated.

The following year, 1856, D. Gooch built eight 2–4–0 fast passenger engines at Swindon, followed by ten of the same class in 1863–4—The Engineer, December 16th, 1910. They were of much more modest dimensions than the type previously described, and had 16in. by 24in. cylinders and 6ft. 6in. coupled wheels; heating surface, 1263 square feet; total weight, 30 tons 13 cwt. These engines also had sandwich frames inside the wheels. They were scrapped after about fifteen to twenty years' service, though their early disappearance may be connected with the reduction of broad-gauge mileage, owing to the conversion of many sections to standard gauge in 1872–4.

Briefly stated, the four-coupled engine never

* No. XV. appeared April 10th.

[1] "Railway Machinery," p. 134.

[2] Sections of an engine of this class may be found in "Proc.," Inst. C.E., Vol. XVI., Plate 1.

succeeded in establishing anything like equality with the single engine on the Great Western broad gauge.

Three types of 2–4–0 express engines on standard-gauge railways merit mention. The first were Hawthorn's engines—THE ENGINEER, November 28th, 1913—built in 1855 for the Great Northern Railway. They had double frames, the outside frames being of the sandwich pattern. The cylinders were 16½in. by 22in.; coupled wheels, 6ft. 6in.; wheel base, 15ft. 9in.; fire-box heating surface, 110 square feet;

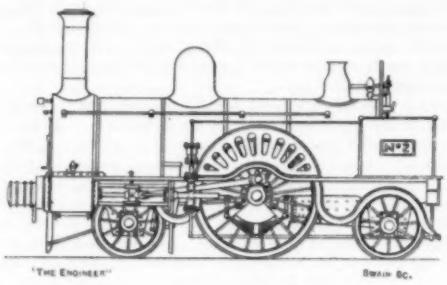


FIG. 114—G. AND S.W. ENGINE, 1857

total 982 square feet; weight in working order about 33 tons.

These engines were not intended to supersede the "singles," which on the Great Northern until the closing years of the nineteenth century remained unrivalled. The coupled engines worked some of the heavier "fast" main line trains at lower speeds, and of the inside cylinder type of that day were probably the most successful.

The Midland also tried coupled express engines. The then existing main lines of this company, with the exception of the section between Birmingham and Bromsgrove, were well suited for single engines, until in 1857 the Leicester (Wigston) to Hitchin line was opened, the gradients on which, between Wigston and

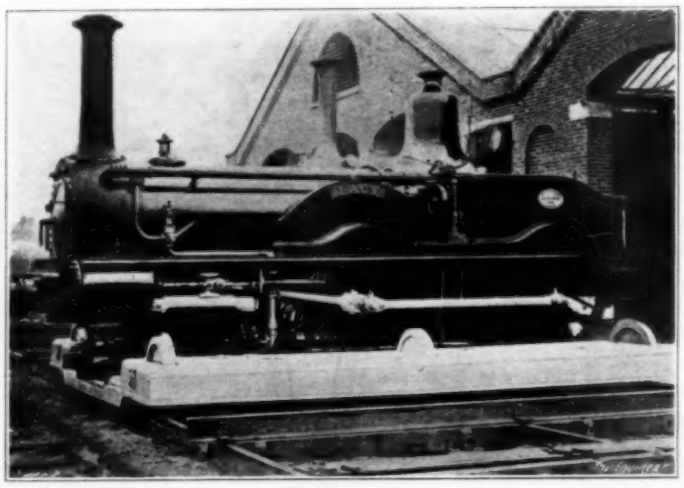


FIG. 115—L. AND S.W. LOCOMOTIVE, 1859

Bedford, were much more severe. For the purpose of working the new London expresses, which from February, 1858, ran on this road between Leicester and King's Cross, four 2–4–0 express engines with double sandwich frames were built at Derby. They had 6ft. 6in. driving wheels and 16in. by 22in. cylinders. As coupled express engines they were a failure, and after about three years' service were converted into single engines similar to the one illustrated in Fig. 111. The reasons for the want of success of coupled express engines will be mentioned subsequently when the subject of single *versus* coupled engines will be more fully discussed.

Joseph Beattie's celebrated 2–4–0 express engines with outside cylinders for the L. and S.W.R., first built at Nine Elms in 1859, are shown in Fig. 115.[3] They were the first engines on the standard gauge to have coupled wheels as large as 7ft. The cylinders were 17in. by 22in.; the wheel base, very short for a main line express engine, was 6ft. 2½in. + 8ft. = 14ft. 2½in. The boiler was provided with Beattie's patent double fire-box and combustion chamber. The front portion of the barrel, 3ft. 9in. diameter, contained 248 $1^9/_{16}$in. tubes with $^9/_{16}$in. clear space between them. Total heating surface, 1149 square feet; grate area, 16.1 square feet; pressure, 130 lb.; weight in working order, 33 tons. Amongst the more interesting details other than the boiler were Allan's straight link motion with reversing shaft underneath the link, and the wedge adjustments of the connecting and coupling rods. Beattie always used horizontal wedges instead of vertical cotters, fine adjustment being possible by means of a screw and nuts.

Of the coupled express engines of this period these were the only ones which may fairly be described as really successful. One of the four 1859 engines was broken up in 1887 after completing a mileage of 869,000.

Other Four Wheels Coupled Engines.—Of these, J. I. Cudworth's standard South-Eastern 2–4–0 engines—Fig. 116—were amongst the most celebrated. They originated with six engines built to Cudworth's designs by E. B. Wilson and Co. in 1856–7, the design being modified in 1859 by the addition of coal-burning fire-boxes with longitudinal partitions. From 1859 until 1875 more than one hundred of the class were built with only minor modifications, chiefly in the length of the sloping fire-box. The cylinders were 16in. by 24in.; coupled wheels, 6ft.; and leading wheels, 4ft. 6in. diameter; wheel base, 14ft. 10in., equally divided. The earlier engines of 1859 had fire-boxes 7ft. 6in. long, which with midfeathers provided 140¾ square feet of heating surface. In later years Cudworth shortened the fire-boxes, reducing the grate area from 22.4 to 19.8 square feet and the heating surface to 113.7 square feet. The total heating surfaces of the two sizes of boiler were 950 and 938.7 square feet respectively; pressure, 120 lb. The sloping fire-box enabled the designer to place the trailing axle underneath instead of behind it, and an excellent weight distribution resulted as follows:—

	Long fire-box engines. T. C.
Leading	9 10
Driving	10 10
Trailing	10 10
	30 10

	Short fire-box engines. T. C.
Leading	9 15
Driving	10 15
Trailing	10 6
	30 16

The design of the fire-boxes will be referred to subsequently.

Scottish locomotive engineers were very partial to a large-wheeled 2–4–0 engine for main line goods traffic. Fig. 117 shows one of these designed by B. Connor for the Caledonian Railway, and built 1858–1864 by Neilson, Beyer Peacock, and at the company's works at St. Rollox. This design, with inclined cylinders, was a direct derivative of the old "Crewe" type, but the engines were considerably larger, having 6ft. 2in. coupled wheels and 18in. by 24in. cylinders. Similar engines with modified boilers were constructed for the Caledonian Railway until the end of 1877.

[3] For complete drawings of these engines see Colburn, Plates XVI. and XVII.

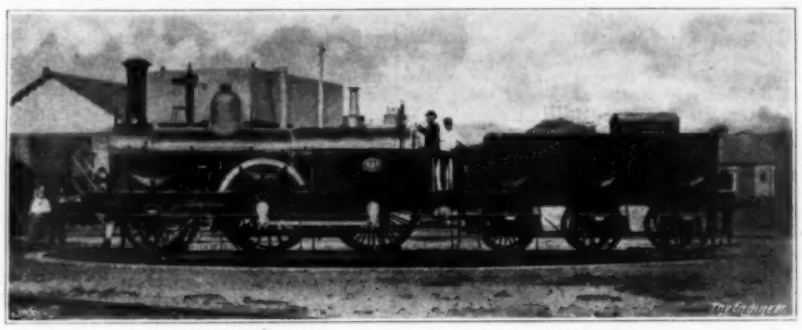


FIG. 116—SOUTH-EASTERN LOCOMOTIVE, 1859-1875

Robert Sinclair's Great Eastern[4] main line goods engines of 1859 by Neilson and Co. were somewhat similar but had horizontal cylinders, inside bearings for the leading wheels, and the Neilson type of flush fire-box casing. The coupled wheels were 6ft. 1in. diameter and the cylinders 18in. by 24in. Subsequently in 1861–1866 90 more engines of the class, but with 17in. by 24in. cylinders, were built by various firms. In them the dome was placed on the middle of the boiler, and large cabs were provided. The boiler barrels were in four rings lap jointed transversely, the first and third rings being of the largest diameter. In the later engines of 1863–6 Sinclair adopted four rings of equal diameter with circumferential butt joints as in Sharp's earlier engines. Compensating levers were provided between the coupled wheels. A cast iron footplate was added to increase the weight at the trailing end, but in those engines of the same class built by Stephenson and Hawthorn in 1861 this casting took the form of a hollow water-box of a capacity of 135 gallons to provide an extra water supply in addition to that in the tender. The total heating surface varied from 1041 in the later to 1079 square feet in the earlier engines. Pressure, 120 lb.; weight in working order, 30 to 31 tons in the earlier engines of 1859 to 1861. The tenders had wood frames with iron horn-plates bolted on.

Four-coupled Mineral Engines.—Several of the leading Scottish railways adopted the 0–4–2 type with outside cylinders almost exclusively for mineral traffic, and these engines were designed by such well-known engineers as Sinclair, Allan, P. Stirling, and Messrs. Neilson and Co. A typical engine by the last mentioned firm was illustrated in THE ENGINEER, December 1st, 1922, page 571, Fig. 4. One of Patrick Stirling's engines for the Glasgow and South-Western Railway, built by Hawthorns in 1857, is shown in Fig. 118. It was one of Stirling's earliest designs, and very unlike his later work. These engines had 5ft. coupled wheels and 16in. by 22in. cylinders.

Bogies: General.—Till this time the bogie had made very little progress in British locomotive practice, and with the exception of the American type engines on the Birmingham and Gloucester Railway was almost entirely confined to broad—7ft.—gauge engines. Of 4–4–0 tender engines the only example was one—possibly two—of the above-mentioned American Norris engines which had had the rear single driving wheels experimentally replaced by two coupled axles, at some period between 1846 and 1850. A 4–4–0 tank engine, designed and built by Stothert and Slaughter, of Bristol, was placed in service on the Monmouthshire Railway about 1850, but does not appear to have been very successful.

On the straight and comparatively well-laid British main lines, there was then very little necessity for

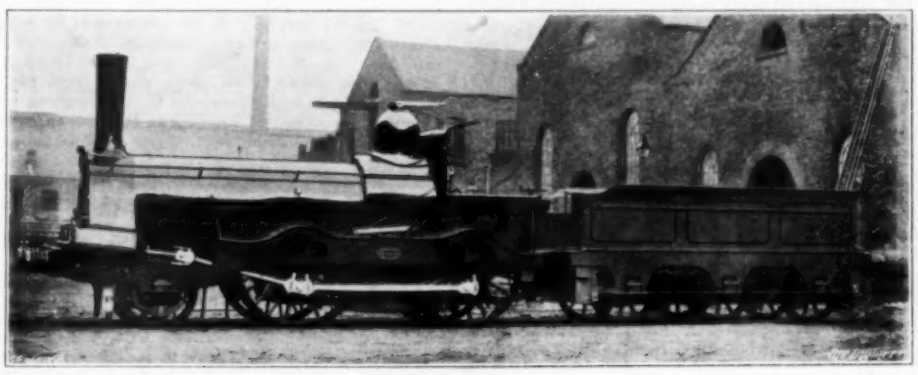


FIG. 117—CALEDONIAN LOCOMOTIVE, 1858-1884

leading bogies. The early bogies turned loosely about a fixed pivot, had no controlling arrangement, and offered such a small resisting moment that they tended to oscillate from side to side, sometimes to a dangerous extent. Their short wheel base was always considerably less than the width of the gauge, the

[4] Clark and Colburn (1860), Plate XLI.

base of the Norris engines being only 3ft. Fernihough, in October, 1845,[5] pointed out this dangerous oscillation, and was the first to suggest that it might be damped by the frictional resistance of a bearing ring of large diameter, and that under this condition the bogie would prove useful. It was nearly twenty years afterwards that both Messrs. Stephenson and W. Adams carried out Fernihough's suggestion in a modified form.

Gooch's 4–4–0 7ft. gauge tank engines of 1849 had a bogie base of 5ft., but their turning movement was so extremely limited by the relative positions of the bearing springs, buffer beam gussets, and cylinders that the engines were hardly more flexible than if they had been of the 2–4–0 type. To assist the curving of these engines the driving wheel tires were made without flanges, so that the guidance of the engine was left entirely to the flanges of the bogie, which, unless the latter had not been an almost rigid truck, would have involved considerable danger. Pearson's 4–2–4 tank engines on the Bristol and Exeter Railway had better bogies with a 5ft. 9in. wheel base, but even in this case the whole guidance of the engine was left to the bogies since the driving tires were flangeless.

With the notable exception of Sturrock's celebrated G.N.R. inside cylinder 4–2–2 express engine, No. 215, of 1853, the bogie of which had a base of 7ft. 2in., it does not appear to have been then understood either in this or in any other country that a bogie with a very short wheel base was not suitable for allowing the engine to place itself in the best position for traversing

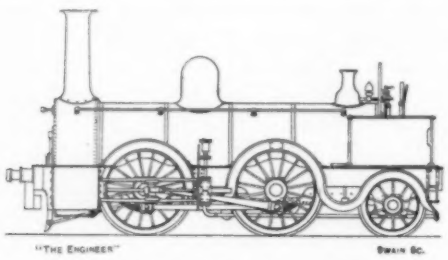


FIG. 118—G. AND S.W. ENGINE, 1857

a curve, especially for turning the head of the engine. The leading bogie with long wheel base was the result of the accidental influence of placing outside cylinders in a horizontal position, so that, to provide room for attaching the latter to the main frames, the bogie wheels had of necessity to be spaced well apart. In the case of the latter bogie some designers omitted to allow sufficient clearance for the turning movement of the leading wheels, and neither cut out the main frames nor bent them inwards, and, in certain cases, the engines refused to stay on the rails even on moderately sharp curves. The result was either the abandonment of the bogies for a time or a return to the older design with bogie of very short wheel base placed far back as in Gooch's engines, thus shortening the distance from the rigid pivot to the centre of the trailing coupled axle. The latter form and arrangement of bogie for engines with inside cylinders disappeared when Adams in 1864 introduced the long wheel base bogie with lateral movement of the pivot controlled by check springs. A similar lateral control had previously been designed by R. Stephenson and Co. in 1861, but does not appear to have been carried out. In Adams's, and also in Cowan's 4–4–0 engines of 1865 for the Great North of Scotland Railway, which had rigid pivots, the frames were properly cut out to secure the necessary turning clearance.

The Mechanical Equivalent of Heat. Joule's First Measurements.

By W. W. HALDANE GEE, B.Sc., M.Sc. Tech.

The value of the mechanical equivalent of heat, symbolised with almost universal consent by J—the initial letter of Joule's name—is now accepted as 778 foot-pounds per B.Th.U. The number obtained by James Prescott Joule in 1843 was higher than this figure by only about 8 per cent. How he obtained this result is not often described in text-books, the authors of which usually content themselves with an account of his later and very different methods in which mechanical work is converted into frictional heat. Now, with the aid of Joule's laboratory books, which are preserved at the Manchester College of Technology, it is possible to give details, not hitherto published, of his initial and very difficult experiments.

1. The Heating Laws.

Joule's discovery of the laws of electric heating—see The Engineer, November 7th, 1924—lead him to very important generalisations relating to electrical energy produced by the conversion of chemical energy in primary cells, and he then proceeded to ascertain if the currents produced by what, nowadays, we should call a separately excited dynamo followed his heating laws. In this task he brought to bear the knowledge and skill he had acquired during six years of arduous research.

[5] Evidence before Gauge Commission, Question 4373.

His experiments with different types of electromagnets and simple electric motors had taught him how best to design a generator suitable for the measurements he contemplated. Towards the end of March, 1843, he had the machine ready for preliminary tests.

The following details and sketch—Fig. 1—are given of it in his historic paper in the *Philosophical Magazine*, Series 3, Vol. 23, 1843, "On the Calorific Effects of Magneto-electricity and on the Mechanical Value of Heat," read before the British Association meeting at Cork. The construction of the armature merits attention; its core consisted of six plates of annealed hoop iron, each 8in. long and $^1/_{16}$in. thick, insulated from each other by oiled paper and then bound together by a ribbon of oiled silk. On this core was wound 21 yards of silk insulated wire $\frac{1}{4}$in. diameter. The armature so made was enclosed within a glass tube, sealed at one end and provided with a stopper at the other end. The method of mounting and revolving is obvious from Fig. 1. To rectify the current the ends of the armature winding

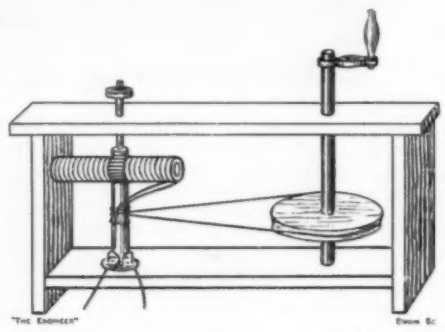


FIG. 1

were arranged to pass to a simple two-part mercury commutator, the extremities of the wires being tipped with platinum to avoid fouling of the mercury. To prevent sparking in the air and oxidation of the mercury the latter was covered with a layer of water.

The field electromagnets are not shown in Fig. 1; they were arranged so as to give a horizontal field of force in which the armature could be rotated. Before making a test the glass tube was filled with a measured quantity of water and its temperature noted before inserting the stopper. The first experiment made with the apparatus is quoted below from the laboratory book :—

March 28th, 1843.—*New Tube with Enclosed Electromagnet. Experiments without Electromagnets.*

Time.	Velocity per sec. of wheel.	Mean T.R.	Dif.	H. of water.
15′	1	47.24	0.38 +	47.75
				47.50 .. Loss 0.25
15	1½	47.21	0.25 +	47.48
				47.45 .. Loss 0.03
15	1⅞	52	0.42 +	52.40
				52.45 .. Gain 0.05
15	1⅞	53.32	0.38 +	53.57
				53.83 .. Gain 0.26
15	1⅞	57.2	0.36 +	57.67
				57.45 .. Loss 0.22
15	1⅞	57.4	0.05 −	57.50
				57.20 .. Loss 0.30

A study of these figures is most desirable, for they show the method followed in dealing with the small changes of temperatures on which Joule's prolonged researches were often based. The time of turning the wheel was in each case 15 minutes, and this was the period of test adopted, with few exceptions, in all the experiments. By counting the number of turns in this time the velocity could be deduced. This was uniform in the last four experiments, showing that Joule was able to turn the wheel in a regular way. In the majority of his later trials he adopted a uniform rotation of the armature of 600 turns per minute. "T. R." relates to the temperature of the room; this abbreviation he adopted from his first researches. It will be noticed that it is given to the $^1/_{100}$ part of a degree, which was that of Fahrenheit. "Dif." requires some explanation. It is the mean difference of the temperature of the water around the armature and the air temperature. Thus : − 47.75 − 47.24 = + 0.51, and 47.50 − 47.24 = + 0.26, so that $\frac{0.51 + 0.26}{2}$ = + 0.385 exactly. Joule regarded this quantity as of importance in helping him to make a correction for cooling or heating. It will be noticed that the last column of figures shows sometimes a gain and other times a loss of heat, and its value being less than a third of a degree, any deductions are valueless. To lessen these fluctuations of temperature Joule proceeded to make an improvement in his armature. He coated the glass containing tube with tinfoil, leaving, however, a narrow longitudinal slit to avoid the production of surface currents. Over the foil was wound flannel, an air jacket being left between it and the foil by fixing small rods of wood. Finally, the flannel was well varnished. On again running the reconstructed armature without the field magnets the temperature losses were smaller than before.

The electromagnets used were two which were originally on one of Joule's first electromotors. The shape of the iron cores is shown in Fig. 2; each was about 44in. long, 3in. broad, and ½in. thick. They were wound with about 100 yards of a six-strand cable, each wire being $^1/_{20}$in. thick. Between the upper and opposite poles the armature was revolved, and the lower poles were joined—beneath the base of the apparatus—so forming a single magnet. For the purpose of excitation six Daniell cells were used. They were of large size, 25in. high and 5½in. diameter. In making an experiment a galvanometer was placed in the armature circuit, care being taken that it was placed at a sufficient distance from the magnet so that its readings were not disturbed by the strong magnetic field.

The results of a long series of tests were not very satisfactory. Joule remarks of them: "Notwithstanding the precautions taken against the injurious effects of radiation and convection of heat, I was led into error by my first trials; the water had lost heat, even when the temperature of the room was such as led me to anticipate a contrary result." He did not find the cause of the anomaly, but decided that if he made experiments with the magnets excited and then not excited alternately, and placed the thermometer, giving the air temperature, so that it was equally under the influence of the field and the revolving armature, then the disturbances could be eliminated.

On April 15th he made a new series of trials, using thermometers which he had compared with great care. The table of corrections is given in the laboratory book. The remark may be made here that the laboratory books record thousands of such comparisons, the readings being estimated to the hundredth of a degree Fahrenheit. The mean result of the new series of tests showed a rise of only 0.10 deg. Fah., when the armature was run at 600 revolutions per minute for 15 min., the current being 0.117 Q = about 0.31 of an ampère.

The magnetic field was evidently too weak. "Availing myself," he says, "of previous experience, I succeeded in producing an electromagnet possessing greater power of attraction from a distance than any other, I believe, on record." The core of the magnet is shown in Fig. 3. The limbs were about 16in. long and the distance between the poles about 10in. Fig. 4 shows the complete magnet. Joule was very pleased with this big magnet, and the laboratory book records a number of interesting experiments showing its magnetic strength. Having a low electrical resistance, it was necessary to reduce the battery resistance by parallel arrangements of the cells to give a sufficiently large current for excitation.

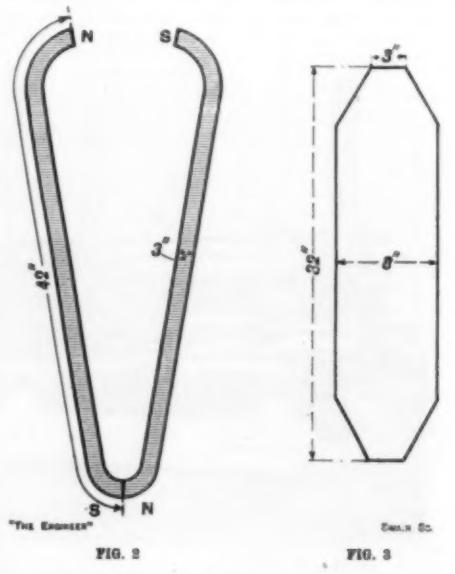


FIG. 2

FIG. 3

The first trial with the new magnet in position was made on May 5th, 1843, and the work was continued morning and evening for several days. As in previous tests, the time of a run, at 600 revolutions per minute, was 15 min., and the magnet was supplied with current from four cells arranged in a series of two double pairs. At each test three readings were made of the galvanometer and four of the air temperature. The summarised mean results for May 8th and 9th give a gain of 0.45 deg. Fah. for a current of 0.418 Q. Joule then ran the dynamo in short circuit, when the rise was increased to 2.39 deg. Fah. The current could not then be directly observed, for the galvanometer was out of circuit, but from a knowledge of the resistances, it was calculated as—

1.019 Q = 1.8 ampères nearly.

He thought that it would be wise to make an independent test by replacing the electromagnet by steel magnets, in which there would be no rise of temperature due to excitation. Accordingly, he made two magnets of thin plates of hard steel. The rise was now only 0.10 deg. Fah. and the current 0.34 Q.

The next step was to ascertain the heat produced by the reversals of magnetism, so he ran his generator *on open circuit*, with various excitations, and also

when the electromagnets were not supplied with current. This led to a separate investigation, to be considered later. It will now be sufficient to note that with the electromagnet supplied with current from ten cells arranged as five double pairs, the rise of temperature due to eddy currents, &c., was as great as 0.28 deg. Fah. in 15 min.

This did not complete the corrections needed. Joule was well aware that the currents given by his generator were alternating, and when rectified by the commutator they were propagated into the outside circuit by pulsations, and so were different from a steady direct current. A factor was necessary to convert the heat corresponding to their galvanometer readings to those produced by direct currents. As a result of a study of the action of the commutator, he came to the conclusion "that the heat due to a given deflection of the galvanometer would be 4/3 of that due to the same deflection and a uniform current." He was not content to accept this estimate without experimental confirmation, and the laboratory book gives the details of the proof under the entry :—"May 11th, morning.—Exps. to ascertain the heat evolved in extra coil by the magnetic electricity." Condensing the observations and including details, it is found that the test was made by immersing a coil of 5 or 6 yards of insulated copper wire, $^1/_{20}$in. diameter, in water contained in a flask. This coil was connected in series with the dynamo and a suitable galvanometer. A run under the usual conditions—of 600 revolutions per minute for 15 min.—gave a rise of 0.43 deg. Fah. for 0.293 Q. He then substituted a steady current from four cells and the rise was 12 deg. Fah. in the same time with 2.02 Q. If both the dynamo current and the uniform current followed the square law, the rise of temperature in the former case should be—

$$\left(\frac{0.298}{2.02}\right)^2 \times 12 = 0.261.$$

This figure is smaller than that actually observed, the ratio between the two being 1.122, and much less

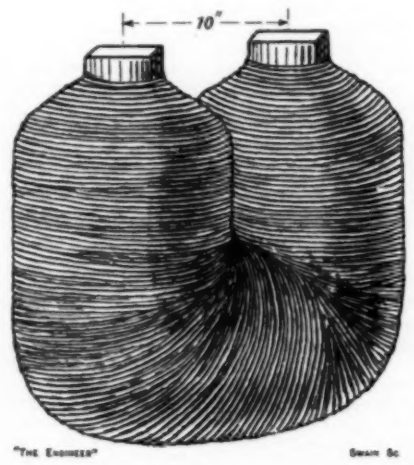


FIG. 4

than the assumed ratio of 1.333. Joule did not further continue this part of the research.

The next and final step was to find the heat produced in the stationary armature with a constant current. The mean result was a rise of 5.88 deg. Fah. in 15 min. with 2.145 Q.

All data having now been ascertained, it only remained to calculate and tabulate the results :—

No. of series of experiments.	Corrected heat of dynamo current.	Corrected heat for steady currents × 4/3.
1	0.098	0.053
2	1.56	1.386
3	0.36	0.299
4	2.11	1.769
5	0.10	0.091
6	0.21	0.197

The figures in the last column are too small. Many years afterwards—in 1881—Joule realised that his factor of 4/3 was incorrect. However, in 1843 he regarded the above results as sufficient to prove that "*the heat evolved by the coil of the magneto-electrical machine is proportional (cæteris paribus) to the square of the current.*"

2. Mechanical and Chemical Energy.

His experimental work had so far indeed been arduous and difficult, but Joule now undertook a still more trying task. Of these whole investigations Osborne Reynolds has said :—"This research was one of extreme difficulty, and as an experimental feat probably surpasses anything ever accomplished." To realise why Joule now proceeded to consider further "the calorific effects of magneto and voltaic electricity," we must refer to an earlier paper, "On the Heat Evolved during the Electrolysis of Water," read at the Manchester Literary and Philosophical Society, January 24th, 1843, in which Joule makes the observations :—"The magnetic electrical machine enables us to convert mechanical power into heat by means of the electric currents which are induced in it. And I have little doubt that by interposing an electro-magnetic engine into the circuit of a battery a diminution of the heat evolved per equivalent of chemical charge would be the consequence, and this in proportion to the mechanical power obtained." In a footnote he remarks that he is preparing for experiments to test the accuracy of this proposition. In brief, what he proposed to do was to place a dynamo and a battery in opposition when the current I obtained would be :—

$$I = \frac{E - e}{R}$$

where E is the E.M.F. of the battery, and e that of the dynamo, R being the total resistance of the circuit.

During May and June, 1843, he made a series of runs. To quote some of the entries :—

"*May 31st.* Wet and still. 8 Daniells to large E magnet ; 2 Daniells in series to elec-magnet (*i.e.*, the armature).

"*June 2nd.* Fine and sultry. 8 Daniell cells to E magnet ; 2 to revolving E magnet. Rotation contrary to the natural direction.

"*June 5th.* Same apparatus, only the velocity increased so as to turn the needle to the other side."

In this last experiment it was found that the two pressures neutralised each other when the speed of the dynamo was about 370 revolutions per minute.

The general result of the tests showed that the current obeyed the laws of electrical heating when a correction for "the mixture of the constant effect of the battery with the variable magneto-current" was applied.

It is not necessary to detail the results, for their only interest, as far as the present purpose is concerned, is that mechanical power was involved, but it will be advisable to state the conclusion that Joule further drew from his results. It was that the heat produced by chemical action is subject to an increase or to a diminution directly proportional to the intensity of the magneto-electricity assisting or opposing the voltaic current. Hence we have "*in magneto-electricity an agent capable by simple mechanical means of destroying or generating heat,*" and he promised next to make an attempt to connect heat with mechanical power in absolute numerical relations.

3. The Mechanical Equivalent.

The question which Joule now put to himself was :—"Does a constant ratio exist between heat and

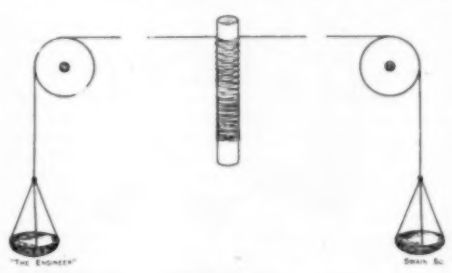


FIG. 5

mechanical power ?" To answer it he realised that it was only necessary to repeat some of his previous experiments, replacing the hand rotation of the dynamo armature by some measurable power. Accordingly, he devised an arrangement of falling weights which became, with refinements, for many years his standard device for the measurement of mechanical energy. The apparatus is shown in Fig. 5. The vertical axle of Fig. 1 to which the handle was attached was wound with a double strand of fine twine. At a distance apart of 30 yards two pulleys, moving with little friction, were fixed, one on each side of the axle. A string from each winding passed over a pulley and a scale pan was provided as shown. By changing the weights in the pans the armature could be revolved with any convenient speed. The date and account of the initial experiment is of historical interest :—

"*June 12th*, 1843. All day exp^{ting} on the power required to turn the app. Large E-magnet with 10 Dan^{ll} in series of 5.

No.		One weight. lb. oz.	The other. lb. oz.
1	Battery contact broken	3.8	3.8
2	Commutator in action, but circuit broken	3.12	3.11
3	Circuit complete (Galvanometer = 23 deg.)	5.12	5.11
4	As No. 2	3.12	3.11
5	As No. 1	3.8	3.8 "

A second experiment on the same day required 2 lb. 13 oz. in each pan to turn the armature at the standard rate of 600 revolutions per minute when opposed only by friction and the air resistance, but 5 lb. 3 oz. when the field was excited and the armature giving a current of 0.983 Q. Twice the difference of the weights = 2 lb. 6 oz., represents the force necessary to produce the electrical current. The rate of fall was 517ft. in 15 minutes. Hence the work used in this time was 4.75 × 517 foot-pounds. So far the measurement was very definite, but now Joule had the difficult task of assessing the amount of heat that this work produced. This heat was employed in :—

A. Heating electrically the armature coil and the external circuit.

B. Heating the iron core owing to the alternating magnetic flux.

C. Producing sparks at the commutator.

In finding A a good series of tests was available. Joule made use of the numbers below taken from his records of May 6th and 8th :—

	Current.	Dif.	Loss or gain.
Magnet excited	0.902 Q	+ 0.51	1.70 gain
Magnet not excited	0	+ 0.36	0.10 loss

The 0.10 loss relates to the cooling, and Joule added this to the 1.70 gain, giving 1.80. To this he made a further correction which was justified by the results of a previous experiment, detailed in the laboratory book but not in his published paper. It is further evidence of the care that Joule exercised in obtaining reliable data. The entry in the laboratory book in an abridged form reads :—

April 24th, Eve.—*Trial to Ascertain the Rapidity of Cooling Apparatus.*

Time.	T.R. mean.	T. of water.
0		94.25
2½	59.7	
7½		
12½		
17½		
20½		86.60
		7.65

In this test the glass tube of the armature was filled with hot water and revolved at 600 revolutions per minute. The cooling was 7.65 deg., whilst the difference between the temperature of the water at the starting of the observations and the mean temperature of the room was 34.55 deg. Joule noticed that the former figure was roughly about one-fourth of the latter difference, and afterwards he always applied this correction. In the example under consideration, one-fourth of the difference of 0.51 and 0.36 = 0.04 nearly, hence the final corrected result for the heating is 1.84. But under the conditions of the experiment 0.28 deg. was due to the heating of the core, hence the rise of temperature in the copper of the armature was 1.84 deg. — 0.28 deg. = 1.56 deg. This figure had then to be increased in accordance with the current, 0.983 Q, measured on June 12th. Applying the law of squares :—

$$\left(\frac{0.983}{0.902}\right)^2 \times 1.56 \text{ deg.} = 1.85 \text{ deg.},$$

but this rise relates to the armature coil alone. To find the rise due to the whole circuit resistances must be measured. It was found that the resistance of the whole circuit compared with that of the armature was as 1.13 to 1, hence the figure for the armature, connecting wires and galvanometer was—

$$1.85 \text{ deg.} \times 1.13 = 2.09 \text{ deg.}$$

Next as to B. How this was ascertained will presently be explained. The estimate was 0.33 deg. Finally, for C. How Joule obtained this correction for sparking he does not fully explain. He gives the figure as 0.04 deg. The total rise A + B + C = 2.46 deg.

To find the British thermal units—Joule does not use this term—the water equivalents of the glass tube, copper of the armature, and the iron core had to be added to the weight of the water. This correction gave a total of 1.114 lb. We have then—

$$2.46 \times 1.114 \text{ British thermal units.}$$

Therefore—

$$J = \frac{\text{Work}}{\text{Heat}} = \frac{4.75 \times 517}{2.46 \times 1.114} = 896.$$

This value, considering all the difficulties of the experimental work, is a remarkable approximation to the value of J. It was followed by two attempts which give the higher values—

$$\text{2nd value of } J = 1001.$$

$$\text{3rd value of } J = 1040.$$

Joule now tried the result of placing the armature in series with a battery. The laboratory book has the entry :—"June 13th.—8 in series of 4 to E. magnet and 2 in series to revolving magnet." Then follow like measurements to the above. These being summarised, show that the dynamo was revolved at 640 revolutions per minute by 2 × 3 lb. 12 oz., the fall of weight being 551ft. in 15 min., with a current of 1.955 Q. It was calculated that the heat evolved in the whole circuit was 9.92 B.Th.U., but since the dynamo and battery were in series, part of this heat was due to chemical energy. To find this latter, the armature was stopped when the current passing through it by the two cells was noted. It was thence calculated that 5.38 B.Th.U. were supplied by the battery. Hence—

$$J = \frac{7.5 \times 551}{9.92 - 5.38} = 910.$$

The dynamo was then run as a motor ; the results of two experiments gave for J 1026 and 587 respectively.

4. Heating of Core.

Joule now realised that his methods were much too complicated and liable to error, and he resolved to simplify the whole procedure. This new work was preceded by an independent investigation, already mentioned, which he had started quite early in this branch of research. The laboratory book has the entry :

"*March* 24, 1843. Exps. with a piece of gun

barrel to see whether heat is evolved by the currents generated in the body of the iron by magnetic induction. Two E magnets belonging to old engine were excited by 6 Daniell, and the heat was observed in the water contained by the gun barrel." The result was a gain of about 0.4 deg. Fah. in 30 min., the speed of rotation being relatively low. It was nearly three months later that he began a systematic set of tests. The results are recorded in the second laboratory book. This, a larger and better book than the old one, contains records from June, 1843, to May, 1858. These are more systematically entered than in the previous book, and constitute an extraordinary memorial of thousands of observations. The second entry is :

"*June 17th*, 1843. Evening hot and fine. Experiments to ascertain the heat evolved by a bar of round iron 8in. by ¾. 10 cells in a series of 5. Electricity passing through E. magnet in 1st exp." Then follow details of the measurements, from which it was found that the water in the glass tube which contained the iron was raised in 15 min. during rotation at 600 revolutions per minute by 1.31 deg. Fah., the current supplied to the large electromagnet being 9.85 Q. On June 19th two further experiments are recorded, using smaller exciting currents. From these three experiments, he concluded that "*the heat evolved by a revolving bar of iron is proportional to the square of the magnetic influence to which it is exposed.*" Since these early researches, the energy losses when iron is rotated in a magnetic field have been thoroughly investigated, especially in connection with the analysis of dynamo tests. The losses are chiefly of two kinds : —(1) Eddy current losses and (2) hysteresis losses due to the reversal of the magnetism through the iron. The former vary as the square of the magnetic flux density B in the iron, whilst the latter vary according to the law of Steinmetz as $B^{1.6}$. In Joule's experiments with the solid bar of iron, it would be chiefly the eddy current losses which caused the rise of temperature, so that this subsidiary research resulted in the discovery of a new law. In connection with what will immediately follow, it should be noted that Faraday had experimented on the heat evolved by the rotation of non-magnetic metals in a magnetic field, and he had proved that the heat varied with the electrical conductivity of the metal, and Joule mentions the importance of this result in obtaining a maximum rise from the revolution of a metallic bar in a magnetic field.

5. The New Method.

After the above research, there is no further record of experiments until the end of October, 1843. In the interval, Joule was arranging his results for publication, and taking a holiday. It is most unfortunate that a page is missing from the laboratory record relating to the new method which he then decided to use. The following details are chiefly taken from the published paper.

The iron cylinder used in the above experiments was electrolytically coated with copper by using a suitable bath and current density. In four days 11 oz. of good copper was deposited, about ¼in. thick. The ends of the cylinder were filed until the iron just appeared. Joule then had a cylinder of iron surrounded by a tube of good conducting power. This was placed (as in previous experiments) in a glass tube, which was filled up with water.

This new short-circuited armature was then rotated between the poles of the large electromagnet, and the rise of temperature, taken with alternations of excitation and non-excitation of the field magnet. Including the usual corrections, there was a gain of 2.73 deg. Fah. for 10.93 Q. in 15 min., at the speed of 600 revolutions per minute.

Turning now to the mechanical side of the measurements, Joule found as the result of the mean of five experiments that 2.1 lb. was the weight required in each scale pan—after deducting the weight required to overcome friction—to revolve the armature at the proper speed. The exciting current was now 10.82 Q. Arranging the results—

Excitation.	Rise of temperature.
10.93	2.730
10.82	2.675 (by calculation from the square law of heat produced by eddy currents, &c.)

The work done was—

$$2 \times 2.1 \times 517 \text{ foot-pounds.}$$

	lb.	Water equivalent. lb.
Weight of glass tube ..	1.125 ..	.. 0.205
Weight of water	..	.. 0.687
Metallic bar	.. 1.688 ..	.. 0.202
		1.094

$$\text{B.Th.U.} = 1.094 \times 2.675$$

$$J = \frac{2.1 \times 2 \times 517}{1.094 \times 2.675} = 742$$

This is most certainly the best of Joule's early determinations, and should be taken as the final result. He himself took the mean of thirteen experiments, including the results of the much inferior methods, which varied from 587 to 1040, as 838.

The research had occupied six months, and when he described it at the British Association it received no comment, and Joule's great discovery remained unappreciated until 1847, when he described to the British Association other methods of finding J. It was then that William Thomson, later to become Lord Kelvin, recognised the great consequences of the law proved by Joule.

This account of the first determination should help in the appreciation of the remarkable skill and persistence with which Joule was endowed. It was the great James Clerk Maxwell who expressed the following opinion of the labours of Joule : "There are only a few men who have stood in a similar position and who have been urged by the love of some truth, which they were confident was to be found, though its form was as yet undefined, to devote themselves to minute observations and patient manual and mental toil in order to bring their thoughts into exact accordance with things as they are."

Shifting a Bridge in Vienna.

In the shifting of the Brigitta Bridge over the Danube Canal some 20 m. upstream an engineering work of a somewhat unusual character has recently been effected in Vienna. The bridge, an iron girder structure, was built in 1871, and has a length of about 67 m. and a breadth of 18.10 m. Its estimated weight is 720 tons. As it was no longer adequate for the increasing volume of traffic, it became necessary to build a new bridge, and as a temporary provision for the traffic during the erection of the new structure it was decided to shift it a short distance upstream. For the purpose two sets of railway tracks carried on piles—one pair of rails on each side of the canal—were employed. The rails were laid on three rows of piles and steel girders 1400 mm. in depth were used to support the ends of the bridge so that the weight might be distributed as equally as possible so that local depressions of the tracks, by reason of the sinking of individual piles, might be avoided. To assist in the work nose pieces—see Fig. 1—were riveted to the ends of the bridge girders and four hydraulic jacks were arranged so that they could operate on the undersides of these extensions. Each of the jacks had a lifting capacity of 300 tons, so that the four of them could exercise an upward pressure of 1200 tons, which provided a margin of some 480 tons with an estimated load to be lifted of 720 tons. As a fact, the manometer pressure registered on each of these jacks was 185 tons, so that a total upward thrust of 740 tons was exerted, a figure which indicates how nearly the weight of the structure had been estimated.

FIG. 1—NOSE PIECES AT ENDS OF BRIDGE GIRDERS

The rails were laid on oak sleepers arranged close together on a bed of concrete formed above the heads of the piles, the rails being of the Austrian railway type, 140 mm. in height. They were laid with a gauge of 1 m. and with a rising gradient of 1 in 200, in order to allow for any possible sinking of the piles.

The weight-distributing effect of the supporting girders was such that the deflection observed on them was only about 2 mm., whilst the greatest amount of yield in the piles was some 0.8 mm. There was no perceptible deflection in the unsupported ends of the bridge girders, which overhung the point of support by about 5 m. The supporting girders were braced by strong transverse struts to give them lateral distributing capacity, and to ensure a uniform load on the piles.

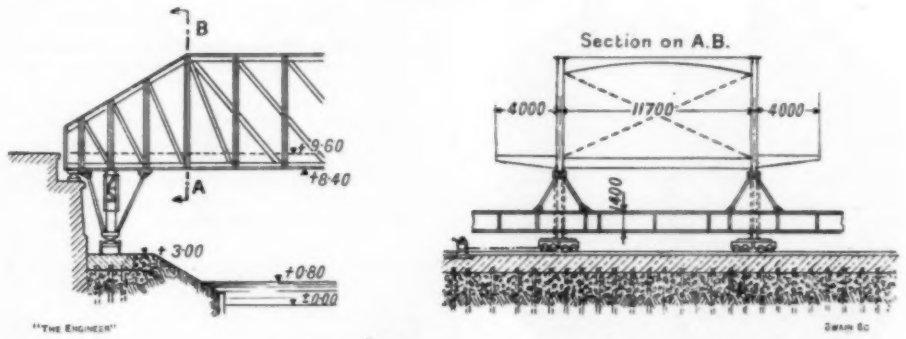


FIG. 2—SKETCHES ILLUSTRATING METHOD OF SHIFTING THE BRIDGE

The construction of the railways was begun in October last, the piles being driven by electric pile drivers. When the driving was completed the bridge was raised a few centimetres and lowered on to wooden platforms 80 cm. wide, arranged between the rails. Traffic on the bridge was suspended and the tramway lines which crossed the bridge were disconnected. The telegraph, telephone and electrical cables had previously been laid on a temporary structure across the canal. The bridge was then again raised, this time by 40 cm. For the work of transportation eight four-wheeled trucks or trolleys—which were coupled together in pairs—were employed.

FIG. 3—UNDERSIDE OF BRIDGE SHOWING SCALE AND POINTER

BRIGITTA BRIDGE OVER THE DANUBE CANAL AT VIENNA

VIEW OF THE BRIDGE JUST BEFORE THE SHIFTING OPERATION BEGAN

When the bridge was raised these trolleys were run underneath it and secured in the desired positions. The bridge was then again lowered until its weight was taken by the trolleys, each pair of trolleys coming immediately under a longitudinal girder of the bridge—see Fig. 2. The work of shifting the bridge then began, two winches, one on each bank of the canal, being employed for the purpose. The operation occupied less than two hours, the bridge being moved at the rate of 1 m. in six minutes. The whole operation was carried out without hitch. To prevent any tendency of the bridge to rack, the lines were most carefully laid and checked, and in a length of about 35 m. the greatest deviation from the parallel of the two sets of rails, which were 67 m. apart, was only 2 mm. To ensure uniform rate of working of the two windlasses on both banks scales were placed beside the tracks and pointers fixed on the bridge traversed them—see Fig. 3. The positions on the scales reached by the pointers were shown in a double-faced indicator placed in the middle, which could easily be read on both banks of the canal. After being successfully shifted the bridge was connected with the roadway at each end, and two days later reopened for traffic. A view of the bridge, taken just before the operation of shifting it was begun, is given above.

The work was carried out by the Waagner-Biro Company, bridge engineers, of Vienna and Gratz. In the competition for the new bridge nine plans for steel and five for reinforced concrete structures were submitted. The plans for an iron bridge from the Waagner-Biro Company were accepted.

Institution of Naval Architects.

No. III.*

AT the afternoon session of the second day of the meetings—April 2nd—Professor C. E. Inglis presented a contribution dealing with "Stresses in Rectangular Plates Clamped at their Edges and Loaded with a Uniformly Distributed Pressure." The principal points brought out in this paper are as follows:—

STRESSES IN RECTANGULAR PLATES.

The deformations and stress in clamped rectangular plates produced by hydrostatic pressure has been investigated experimentally by Crawford, Montgomerie and others. The analytical investigation of the problem is, however, practically unexplored, although the mathematical treatment for a rectangular plate freely supported at its edges is well established. Formulæ for the determination of deflections and stresses in clamped rectangular plates have been advanced by Grashof and have been fairly widely accepted, although they are more or less empirical in character. The object of the paper is to discover how far Grashof's formulæ agree with calculations based on the laws of elasticity. It is claimed that the results given in the paper are exact, in that they satisfy the laws of elasticity. The only departure from the ideal, it is stated, lies in the fact that the edges of the plate are not encastered with absolute perfection, although the degree attained is very high, and is far better than could be counted upon in actual practice. The method of analysis adopted consists of the choice of a suitable particular integral which satisfies the fundamental differential equation deduced from the laws of elasticity, which gives symmetrical deflections in each direction of the plate, and which makes the deflection zero round the boundary; and the superposing on this particular integral of a complementary function, which attends to the boundary conditions, and which makes the rate of change of the deflection zero at the boundaries. For a square plate it is shown that the formula arrived at for the central deflection yields a result which is about 12 per cent. less than that calculated by the Grashof formula, while the maximum tension and compression stresses exceed Grashof's value by about 26 per cent. It is noted that Crawford's experiments implied that Grashof's value for the maximum stresses should be multiplied by about 1.25, a result agreeing very closely with that estimated from the author's calculations. Similar treatment is accorded to a 2 to 1 rectangular plate, and it is again shown that the Grashof formulæ over-estimate the central deflection and under-estimate the maximum tension and compression stresses. The results do not agree quantitatively with those obtained experimentally by Montgomerie with a 2 to 1 clamped plate, and it is held that a suggestion previously made that the plates used by Montgomerie were not clamped in an ideal condition is substantiated.

* No. II. appeared April 10th.

Mr. C. E. Stromeyer welcomed the paper as providing the solution to a problem which had puzzled engineers for a long time. The work done had also opened up a fresh field of investigation. The theory advanced was fully borne out by practical experience.

Professor Kriloff dealt at some length with the mathematical aspects of the paper. He said that the problem which had been attacked first came under review in 1812, and about twenty-five years ago was the subject of a prize offered by the French Academy of Science. The work had also been taken up at St. Petersburg—as it then was—in 1901 and 1902, and had been dealt with from a practical standpoint by tank experiments. Professor Inglis, also, had dealt with the practical side, and his paper should be studied by all shipbuilders.

Professor T. B. Abell said the contribution now made to the Transactions of the Institution was the culmination of years of work. The results given should prove sufficient for all ordinary purposes. He regretted that the work had not been done twenty years ago.

Sir James Henderson congratulated the author on the fact that his results could be used in practice, and hoped that his work was the beginning of closer relations between the mathematician and the engineer.

Mr. F. Bailey, who sent a written contribution, which was read by Mr. Payne, gave some details of a similar investigation to that made by Professor Inglis. He had dealt with other ratios of length to breadth of plate than the square and 2 to 1, and the agreement with the results reached by Professor Inglis was very close. He ventured to submit, however, that his conclusions were more correct as they referred to boundary conditions which were more correctly fulfilled. For practical purposes the 2 to 1 plate could be regarded as of infinite length.

Two papers by Mr. G. Vedeler, "Notes on the Rolling of Ships," and by Mr. H. J. R. Biles on "Model Experiments with Anti-rolling Tanks," were the subjects of a joint discussion. In the absence of the author, Professor Welch gave a short account of Mr. Vedeler's paper, which is of a theoretical nature. The following is a brief summary of Mr. Biles's paper.

MODEL EXPERIMENTS WITH ANTI-ROLLING TANKS.

This paper presents the results of a series of experiments carried out at Glasgow University with a navipendulum or rolling machine, and a model fitted with anti-rolling tanks of the earlier Frahm type. After referring to the work of other investigators, the author described the machine, model and resistance gear and the modifications which were carried out in order to enable him to make the experiments described. Summarising the results obtained, Mr. Biles shows that anti-rolling tanks are more effective when the ratio period of tank water to ship—isochronous—is 0.79 than when it is approximately unity. On uniform waves over a range of wave length in the region of synchronism, the tanks were found to reduce rolling, but for shorter or longer uniform waves the tanks tended to increase rolling. With waves of smaller effective length, say, than 400ft. and 3 deg. effective slope, no serious rolling may be expected, but experiments are needed to see the effect of, say, 12 deg. or 15 deg. slopes at these smaller lengths. On all the irregular waves experimented with, with the exception of some 6 deg. waves, the tanks were shown to reduce rolling. It was shown that with a period ratio of tank water to ship of 1.02 the tanks increased rolling slightly. Further experiment is desirable with shorter and steeper waves of varying wave-slope. The paper is illustrated with drawings and curves.

Mr. N. J. Berry said that the information given in Mr. Biles' paper appeared to indicate that the anti-rolling tank was most effective at wave lengths which were not usually experienced at sea. Tanks had been fitted in H.M.S. Conqueror and King George V., but had not proved effective, and as the space was required for other purposes when war was declared, the tanks were removed. A further trial was to be made, however, in H.M.S. Vivian.

Mr. Maurice Denny said that the problem of rolling was very interesting. It used to be the opinion that to limit rolling a small metacentric height was desirable. Sir John Biles held the view that the tendency was to make the modern ship tender, but he challenged that statement. Shipbuilders had all come round to the belief that a ship must have positive stability when light in dock. On the general subject of rolling, he feared that that quality in a ship did not receive sufficient consideration. Other qualities were considered of more importance. Experience with the anti-rolling tank did not seem to have been encouraging.

Professor Kriloff gave a brief account of experiments with anti-rolling tanks of the Frahm type, carried out when discussion arose as to whether tanks should be fitted in the Russian warships of the 1913 programme. A sum of £15,000 was placed at his disposal for an experiment in a vessel 350ft. in length and of 3500 tons displacement. The results were inconclusive.

The first business before the morning session on April 3rd was the election of new members and the amendment of the rules.

Sir John Biles, in moving the amendment to the rules, said that the changes which were proposed had been under the consideration of a Committee which had given a good deal of time and thought to the subject. The ideas of the Committee had been communicated to the Council, and had been adopted with some modifications, which were an improvement on the original suggestions. The intention underlying the changes was to stiffen up the conditions of membership of the Institution. Membership was being looked upon more and more as a criterion of ability in naval architecture and marine engineering, and it was felt that the Council had not only responsibilities to its members, but to the general public. The Institution was founded sixty-five years ago, and it was not until the year 1889 that any change took place in the conditions of membership, and nothing had been done since. It had therefore been decided to tighten up the regulations governing the admission of students, as well as the requirements for associate and full membership. The new rules, he explained, provided that election as an Associate Member should in future be limited to those furnishing adequate proof of training, either through apprenticeship or pupilage over a period of five years, a mixed training of four years, or that the candidate had obtained a suitable technical education. They also provided for full membership to be granted only

on evidence of ten years' employment in positions of responsibility in shipbuilding and marine engineering work or on proof of occupancy of a position of primary responsibility for a period of five years, if already an associate member, or of seven years if not an associate member.

Sir Alexander Richardson seconded the resolution, which was adopted without dissent.

A paper was then presented by Mr. E. Blocksidge on "Tonnage Legislation and its Application to the Measurement of Ships," of which the following is a summary :—

TONNAGE LEGISLATION.

There is a growing desire among the shipping interests throughout the world for an early investigation into the present application of the regulations controlling the measurement of ships for register tonnage. The British law is the foundation upon which most other countries have framed their regulations, and the author, after dealing with the administration of the present regulations, surveys the basis upon which they have been built up. Particulars of tonnage for the world and for the chief maritime countries are given, both in tables and curves, and it is shown that the net register tonnage is not now an index of the carrying or earning power of the ship. Some legal decisions which affect important features of the British tonnage regulations are then passed in review and the conditions governing 'tween deck and propelling power allowances are described. In the author's opinion the rapid progress made in propelling machinery during the past fifteen years appears to call for a revision in the scale of allowance for deduction from gross tonnage and the substitution of an allowance for the machinery space which will be more accurately in accord with the type and service of the ship. In a table included in the paper tonnage particulars of twenty-five ships fitted with different types of propelling machinery are given. Finally, the unification of the tonnage regulations of the principal maritime countries is discussed and the chief proposals put forward for alterations in the measurement of tonnage are enumerated. It is suggested that it is possible to simplify the regulations and to provide an equitable basis for taxation as between those who pay and those who receive dues on shipping, as well as bringing about uniform agreement regarding the measurement of ships for tonnage purposes.

Sir John Biles, in opening the discussion, said that the tax ought to be based on gross tonnage. A vessel of the Mauretania type had a net tonnage which was only 26 per cent. of the gross tonnage, and yet the large expense incurred by dock boards, particularly the Mersey Docks and Harbour Board, was largely on account of that type of ship, which by reason of low net tonnage paid a disproportionately small amount in dues. For that and other reasons, in any change of regulations which was made, the taxation should be based on gross tonnage.

Mr. John Anderson assumed that the object of the paper was to direct attention to the need of devising a system which would ensure equitable treatment of all ships. It could not be disputed that the existing regulations restricted development, and designers were well aware that a change in the regulations governing measurement of superstructure would enable the range of stability of many ships to be increased. Owners of high-powered vessels of fine form found the present rules satisfactory ; those who owned low-powered ships or intermediate liners, or who wished to adopt new types of propelling machinery for vessels in those classes, might be called upon to bear an unfair burden. Much of the dissatisfaction at inequality of treatment arose out of the admittedly preferential treatment granted to steamships in 1834, and if allowance for propelling power were deleted entirely the greatest source of dissatisfaction would be removed. The measurement of superstructures would not be strongly contested. The only sound principle to adopt was to charge on the basis of the service rendered.

Mr. E. F. Spanner said that the existing system of tonnage measurement was conceived originally with the intention of providing a basis for the charging of dues which it was thought should vary in proportion to the earning capacity of a ship. The original incidence of this charge might have been fair, but the balance had been disturbed by the evolution of new types of vessel and new methods of propulsion, and the present state of affairs was chaotic. It would be foolish to persist in a complicated system of tonnage measurement which gave rise to endless difficulties and disputes, and which was not fair between ship and ship. The best plan would be to determine the tonnage figure on the basis of length, breadth and draught over a constant.

Sir Charles Sanders, who for many years had charge of the tonnage work at the Board of Trade, said that he knew the incentive to the ship designer in the interest of the owner to incorporate features with the sole object of producing a low net tonnage figure. If a simple and fair method of assessing tonnage could be devised, which would be accepted internationally, it would constitute an important reform.

Mr. Blocksidge, in a brief reply, expressed his agreement with Sir John Biles and Mr. Anderson and others who had spoken. The policy he advocated was revealed in the paper. It was necessary to set up a scientific system of tonnage measurement, and he was of opinion that it should be based upon draught.

Mr. W. G. Cleghorn brought up for discussion a paper showing the "Influence of Trading Conditions on the Design of Intermediate Passenger Vessels," the main points of which are set out in the following :

TRADING CONDITIONS AND INTERMEDIATE PASSENGER VESSELS.

The intermediate type of liner for both passenger and cargo is the outcome of existing trading conditions. This paper presents an attempt to analyse the influence which trading conditions have on the formulation of the cargo carrying requirements of a vessel of given passenger-carrying capacity. Assuming a given deck area of 120,000 square feet for passengers and crew and a service speed of 16 knots on a 3000-mile voyage, with a given breadth and moulded draught, the author takes geared turbine oil-fired installations and the necessary bunker capacity, and with the deadweights consequent on these requirements, associates cargo deadweights up to some 14,000 tons. Three different types of vessel are investigated with accommodation for passengers and crew on four, five and six decks respectively with 30ft. moulded draught and a further six-deck vessel with a reduced draught to eliminate the cargo deadweight. By varying the block coefficient of each type sixteen comparisons are made, and are given in table form, the return per voyage is calculated for four different passenger rates and four cargo rates. The return per voyage is taken as being given approximately by the area of accommodation multiplied by the passenger rate, to which is added the cargo dead-weight multiplied by the cargo rate, the cost of fuel for the voyage being deducted and the whole divided by the initial cost of the ship. The results are expressed in tabular form. Investigation shows that the determination of the most suitable cargo-carrying capacity appears to be a question, not only of type, but also of block coefficient, and in connection with this latter factor there is need for further model experiment research.

Dr. Percy Hillhouse thought that experience showed the best all-round ship to be a vessel of about 550ft. long, and Mr. Cleghorn's analysis indicated that that was the type which met the requirements of an intermediate passenger vessel.

Mr. John Anderson agreed with the author as to the need of more model experiment work to elucidate the economic aspects of the subject in greater detail. With the object of arriving at the type of vessels which would be the most efficient for the service in view, it might be desirable to experiment with varying forms of fixed block coefficient. The author had not perhaps been quite fair as regarded the dimensions and first cost of the non-cargo-carrying vessel, and further analysis would probably show this type of ship in a more favourable light.

Mr. Thomas Graham expressed the opinion that to get good draught on all conditions of loading, the light service draught was the best basis to start from. The ship with .65 block coefficient appeared to give the best results under all conditions. The tendency had been to pay too much attention to maximum conditions and too little to ordinary service conditions. In the case of the intermediate ship, more attention must be paid to capacity and less to deadweight, as only by a proper reconciliation between those two qualities could a high degree of efficiency be secured.

Mr. Cleghorn, in concluding the discussion, said that reference had been made to the importance of capacity, but he would remind Mr. Graham that in investigating so many forms of ships it would have been extremely difficult to deal with the capacity of vessels under varying conditions. He agreed, of course, that capacity was an important quality in the intermediate type liner. With regard to the vessel having 0.65 block coefficient, that was a fairly good average.

Mr. G. Frodsham Holt then presented a paper on "Stability and Seaworthiness," of which the following is a *précis* :—

STABILITY AND SEAWORTHINESS.

This paper is devoted to a consideration of the criteria for stability and seaworthiness in ships. In defining a standard of safety the author states that the first condition essential to seaworthiness is that the ship shall never be unstable when upright, at the beginning or the end of any given voyage, or while at sea. While the second condition of seaworthiness is that the worst conjunction of wind and waves that can possibly be encountered during the given voyage shall not cause the ship to roll beyond the safe effective range of heel. He then proceeds to discuss safe initial stability and the safe effective range of heel, after which the subject of rolling among waves and the effect of wind and waves is analysed and illustrated by curves. After defining safe rolling and the safe range of heel when bulk cargoes are carried, a standard of safety and its practical application is outlined. Reference is made to the practical methods of testing a ship's stability by inclining the ship and determining the metacentric height and by observing the rolling period. With the latter methods use can be made of a stability meter with which the author has been experimenting. When calibrated by means of an inclining experiment a stability scale can be prepared from which the frequency of rolling at any time can be converted by inspection into metacentric height. This instrument is designed to be used aboard ship under working conditions, and experiments have given results which will be, it is hoped, soon corroborated in practice.

Professor T. B. Abell opened the discussion. He said that at the present time, owing to losses which had occurred during the past year or two, the question of stability in ships was all important, and the disasters which had been reported had prompted Mr. Holt to devise a scheme by which the stability of a ship could be determined before going to sea. The character of the cargo was an important factor, and unless proper precautions were taken in the case, for example, of a cargo of small coal, which represented practically the same conditions as wheat or grain cargoes, trouble might arise. The master of the ship was responsible for seaworthiness and stability. He was given certain information by the owners which the master sometimes understood, but which he frequently did not appreciate at its full value, so that it was desirable that the master should be able to verify the conditions of his ship. Mr. Holt's instrument should prove very useful for this purpose. What the master desired to know was the least metacentric height and also the metacentric height at any given time, and that could only be determined in harbour by the use of an instrument similar to that described in the paper.

Dr. H. M. Robb thought that Mr. Holt had been unduly modest regarding his solution of the stability problem. The most important point brought out in the paper was that he believed for the first time in the history of the Institution an attempt had been made to present a standard of stability. It had been the custom hitherto to base opinion on that subject almost entirely on the value of the metacentric height, while there was a want of agreement as to what that height should be. It was necessary to decide what the standard of stability ought to be, and it was the duty of that Institution to deal with the matter. Holding this opinion, he formally moved that a Committee be appointed for the purpose of dealing with that subject.

It was stated in reply to this suggestion that Dr. Robb's proposal would be referred to the Council for consideration.

Mr. Woollard communicated some comments prepared by Mr. W. J. Berry. He said that the author of the paper had undertaken the rather difficult task of determining a standard of safety, *i.e.*, stability and seaworthiness, which could be applied to a ship by the designer and even worked to by the master. A good deal of what was contained in the paper was not open to dispute ; a ship should certainly be stable in all conditions when upright, and have sufficient positive metacentric height to prevent undue heeling when under helm, or when damaged in a wing compartment. Hitherto it had, generally speaking, been considered preferable to fix the metacentric height to be obtained in a new design largely by experience. One point was open to criticism. The author suggested 55 lb. per square foot as a standard wind pressure, but that figure was excessive when applied to estimate a ship's heel or roll under a sudden gust ; for a large ship about a quarter of that amount should be nearer the truth. Work of this character would be of far greater value when it has been fully tested.

Mr. E. F. Spanner pointed out that initial stability was only one of the factors which affected seaworthiness. Freeboard and the character of the weather-deck closing appliances were possibly of far greater importance in many cases than initial stability. It was obvious that a liner with a very slight negative stability, but having a large freeboard and substantial and efficient appliances for closing deck and side openings, would be quite seaworthy, *i.e.*, she would be fully equal to the task of carrying her cargo and passengers safely from her port of sailing to her destination even through very bad weather conditions. On the other hand, another vessel with a good margin of initial stability, but having less freeboard and inferior hatch-closing arrangements—although they might be up to accepted standards—might be placed in considerable peril and even be lost. The question of seaworthiness must be viewed from a broad standpoint. There were many difficult and intricate points to be considered, but Mr. Holt's work was on new lines, and he looked forward to the further report promised after experience with the instrument under sea-going conditions.

Mr. Holt, in reply to the points raised, said that under present-day conditions ships were in greater danger of being lost than most people believed. The importance of stability and seaworthiness was, of course, generally recognised, but he had never seen any definite standard for stability put forward excepting Sir Archibald Denny's proposal some time ago suggesting figures for metacentric height and righting lever. He could not agree with Mr. Spanner that a ship might be seaworthy even though it possessed only a negligible metacentric height. He had applied his standard to a number of different ships, and his investigation tended to show that it was desirable for a ship to have as low a metacentric height as possible without falling below the critical limit. His instrument was about to be tested on a vessel under sea-going conditions.

Mr. E. V. Telfer presented a paper by himself and Mr. A. H. Haver, on "The Propulsive Performance of the Corrugated Ship." We give a *précis* of it below :—

PROPULSIVE PERFORMANCE OF THE CORRUGATED SHIP.

In the evolution of the corrugated ship it was found that by forming a groove by the addition of two adjacent bulges along a vessel's sides, and by suitably shaping and disposing these corrugations, a reduction in power of the order of 16 per cent. was apparently realisable in vessels of full merchant ship form. The first vessel of this type to be built was the Monitoria, with a length of 279ft. between perpendiculars, and a block coefficient of 0.79. Since that time upwards of twenty vessels have been constructed, all with block coefficients of the order of 0.78, and have done all that was predicted for them. The performance claimed for corrugated ships has been called into question by some authorities, owing to the fact that experiments carried out in a Froude Tank on a model of the Monitoria seemed to show that the resistances of this ship would be greater than that of her plain sister ships at the same displacement. While the performance of the Monitoria and the plain sister ships did not endorse the Froude Tank experiments, they definitely did endorse those carried out in the Pendulum Tank. The subject of experimental model technique is reviewed, and reference is made to the recent work of Dr. Bothezat ? Dr. Kempf's experiments on the frictional resistance of pipes of 35 mm. and 35 cm. diameter, and Gebers's research on the resistance of planks. Evidence is adduced in support of the argument that when testing a corrugated ship model in a Froude Tank an excess resistance is inevitably developed, and means are proposed whereby this additional resistance may be allowed for. The remaining part of the paper is devoted to a description of experiments recently made at the Vienna Tank on self-propelled 18.15ft. models of the lately constructed corrugated ship Rio Azul and a plain ship of identical normal form and displacement. The method of carrying out the tests is described, and a complete account of the results obtained is given, both in tabular and graphical form. The tables give the thrust, torque, revolutions and shaft horse-power corresponding to speeds of from 8 to 13 knots, and show the superiority of the corrugated design. It is implied that conditions are obtaining which enable the propeller to work behind a corrugated ship with less augment of resistance than behind a plain ship. The progressive load trials of the s.s. Azul on the Whitley Mile are given and are analysed. Results are submitted by the authors to show that the corrugated ship constitutes something of an advance in the design of full merchant ship forms. It constitutes a type of advance that could hardly have emanated from any of the recognised

experiment tanks for the reasons explained. That it was made possible by the Pendulum Tank is not without interest and even explanation. In this tank the small size of model and the fact that its speed varies from zero to a maximum at the similitude speed brings the Reynolds number referred to the corrugation radii within the laminar range. The resistance coefficient in this range corresponds in numerical magnitude with that of the higher Reynolds numbers, and hence with the turbulent conditions of the ship. The corrugations do not have their resistance exaggerated, and hence a reliable comparison of plain and corrugated ship performance is obtained. Some idea of the reliability of the system may be gathered from the fact that when analysing the trial results of the Rio Azul by the method previously described, it was found that the best curve which would lie along the observed spots was that determined from the Pendulum Tank a year previous to the vessel's load trial.

Mr. W. J. Berry, in opening the discussion, said that the authors had shown enterprise in obtaining data in support of the advantages claimed for the corrugated ship. He could not, however, accept the reasoning which suggested that the model with a proportionately reduced radius of curvature had a relatively greater frictional resistance, and that they masked the effect of the corrugations. An independent Admiralty observer attended the trials of the Rio Blanco on the Hartley mile, but that ship gave a poor performance in comparison with the results recorded for the Rio Azul, which made half a knot better speed. The statement that the bad weather conditions handicapped the Rio Blance could not be regarded as a real explanation, as the sea conditions were not in any way unusual. Moreover, it was stated in the paper that the corrugated ship should give a better propulsive performance than the ordinary plain type of ship in all weather at sea. The superiority claimed for this design of ship required more demonstration than was as yet available. Trials made with two models, one corrugated and the other plain, would very quickly prove if the corrugations made any difference to the performance of the ship, but apparently the authors did not trust the ordinary laws of comparison for their particular design. Long experience indicated that in Admiralty vessels of fine block coefficient, any departure from ordinary ship-shape form in the sections always involved greater resistance to propulsion.

Mr. G. S. Baker said that the authors gave the results of model trials in a German tank, and to support their argument introduced a number of extraneous and controversial subjects. On the results recorded it was claimed that at the same speed—12 knots—the corrugated ship would require an indicated horse-power of 2670, and the plain ship 3050. He had hoped to compare these results with figures obtained at the Froude Tank, but the firms for which the trials were made refused to allow definite figures to be made public. Taking the authors' figures, they showed that the propulsive coefficients of the plain and corrugated ship were equal at 8 knots, but that at 10¼ knots the corrugated ship was 2.5 per cent. better. The National Tank tests showed that the power required for the corrugated ship exceeded that for the plain ship, although only by a very small amount, and his own opinion was that there was very little or nothing in it. He had analysed a considerable amount of log data published by Mr. Haver, and on his own figures the plain and corrugated ships plotted together. He was able to give the results of practically sister ships working on the same route and under the same conditions, and they indicated that the plain ship had carried a given amount of cargo on practically the same coal consumption as the corrugated ship, but in a somewhat shorter time.

Mr. George Humphreys, while not claiming the ability to make intricate analyses, said that he had evidence that the coal consumption per day of the plain ship was 14.7 tons and of the corrugated ship 13.5 tons.

Admiral Taylor referred to the difference in torque of the two models, which was in favour of the corrugated ship. A possible explanation was the difference in the draught of the two models. The thrust deduction factors were also different, and he felt that there must be some definite effect due to the difference in the submersion aft. With regard to the suggestions put forward, in the light of Dr. Kempf's work, as to the effect of the corrugations, that was rather speculative, and he agreed with Dr. Kempf, who had said that not enough work had been done to cover the whole ground.

Professor T. B. Abell discussed the effect of the difference of 6in. in draught in modifying the thrust deduction and wake factors. The paper reminded him of the "Hunting of the Snark," one of the weapons used was hope. He noted that it had apparently been found necessary to suggest that Rayleigh's laws required modfication to explain the corrugated ship. It had to be admitted that the propulsive problem had not been solved, although he confessed that marine superintendents might be able to demonstrate to shipowners that that was a saving associated with the corrugated ship.

Mr. John Tutin, in a long contribution, directed attention to two main points:—(1) Was there any reduction in hull resistance arising from reduced skin friction, reduced form resistance, reduced wave resistance, and (2) was there any improvement in propulsive efficiency due to an increase in propeller or hull efficiency or reduced thrust, torque or shaft horse-power? He thought the corrugations would increase skin friction, and found no evidence of a reduction in form resistance. It was impossible on the information given to state whether there was a reduction in wave resistance. Propeller efficiency in the open was presumably the same for both the plain and the corrugated ship, but the best propeller for the corrugated ship was not necessarily the best for the plain ship. The remaining factors—thrust, thrust deduction, hull efficiency, torque, revolutions and shaft horse-power—were interdependent to an extent which made a critical analysis very difficult. Reviewing the paper as a whole, it could not be said that any reduction in resistance had been established. The reduction in shaft horse-power claimed was within the limits of experimental error, and was certainly very remote from the 16 per cent. referred to in the paper.

Mr. M. P. Payne suggested that if, as the authors claimed, the presence of the corrugations was an advantage they might be extended all round the bottom of the ship, and increase that advantage to an extent which would remove it from the realm of debate. He found it difficult to understand as the lower corrugation in the existing ships fitted with this device ended 50ft. from the stern, how it could have any effect of an appreciable character on the thrust deduction.

Mr. E. F. Spanner pointed out that the arguments adduced against any advantage being associated with the corrugated ship had not disposed of the fact that superintending engineers and shipowners were satisfied with the results of these ships in service. He had no interest in the invention, but the fact that the ship was believed in by the practical man who was prepared to put up his money was a definite point. The controversy as to the claims put forward by the advocates of the corrugated ship seemed to turn on the difference between actual service results and those which would be predicted from tank experiments.

Mr. A. H. Haver also commented on the advantage of the corrugated ship under sea-going conditions, and said that he had no doubt in his mind that the corrugations had the effect of reducing resistance. Whatever the results obtained in the Froude Tank, there was no doubt that the tests made in the Pendulum Tank revealed the superiority of the corrugated ship. One feature of the corrugated ship was that it did not roll.

Mr. Telfer replied briefly to some of the points raised in the discussion.

Sir Archibald Denny proposed a vote of thanks to the Duke of Northumerland, who had so ably presided at practically all the meetings which were held. In his brief reply the President complimented the members on the high average of the papers read and the excellent attendance at the meetings. Such interest shown at a time of great trade depression was, he said, a great credit to the Institution.

Mr. W. J. Luke expressed the thanks of the meeting to Mr. R. W. Dana, and referred to the much appreciated work of the secretary and his staff. He congratulated the Institution on its return to the original place of meeting, the Royal Society of Arts. In his reply Mr. Dana paid a tribute to Mr. A. Dansie's work in connection with the arrangements for the annual dinner, at which about six hundred guests and members were present. The 1925 spring meetings will be remembered among some of the most successful of recent years.

Recent Developments in Corrosion-Resisting Steels.

There was a very satisfactory attendance at a meeting of the North-Western Branch of the Institution of Mechanical Engineers which was held recently at the Engineer's Club, Manchester, to hear Dr. W. H. Hatfield's paper on corrosion-resisting steels. Professor Gibson was in the chair. The author opened with a dissertation on corrosion as it affected ordinary ferrous metals and expressed the view that, generally speaking, the results as regards structural and engineering steels were not so serious as was frequently stated. Nevertheless, he said, corrosion as regards ferrous materials was an important subject for the engineer, and it was useful to review the results of research and experience throughout the last few decades. The results of comparative corrosion tests performed on structural and ordinary engineering steels in a range of acids and corroding media were considered, and it was shown by tables on the screen that the presence of oxide of iron or high sulphur and phosphorus content facilitated attack upon the materials. It was also stated that dead mild steels with a considerable manganese content were much less resistant, particularly to marine conditions, than the wrought irons. The indifferent behaviour of mild steels was more marked when the steel was produced by processes involving over-oxidation of the liquid steel during the process of manufacture.

The improvement in the resistance to corroding influences which resulted from the addition of special elements to steel, was next considered, and it was indicated that modern research had demonstrated that only by the addition of substantial percentages of chromium or nickel or chromium and nickel, could effective corrosion resisting steels suitable for engineering purposes be produced. Attempts to influence the resistance of steel by the addition of small percentages of various elements had proved ineffective, as was typified by the unsuccessful attempts which had been made to improve steel by small additions of copper. Nickel added in substantial amounts, namely, from 25 to 30 per cent., had a profound effect in increasing the resistance of steel to a number of corroding media, but the first real economic advance had resulted from a study of the steels included in the iron-carbon-chromium system. It was found that as regards that series of chromium steels, there was for many purposes an optimum percentage of chromium of 13 to 14 per cent., which when present with a carbon content ranging from 0.35 per cent. down to under 0.10 per cent., produced an extremely valuable series of steels, which were resistant to most atmospheric and food influences. Such steels suitable for purposes requiring the characteristics of hardened steel, the machining and mechanical properties for engineering purposes, or a substantial ductility as required for many minor purposes, might be obtained. The resistance of such steels was, however, naturally only satisfactory as regards a limiting range of corroding media, and the author proceeded to show by experimental evidence that if, along with the still higher chromium content, a substantial proportion of nickel were added, complete resistance to a much wider range of corroding media was obtained—as illustrated by the following table. Although the 14 per cent. chromium steels resisted many reagents, there were, he said, a number which they did not resist. The following table gives examples of instances in which the higher chromium-nickel steel is successful, and the 14 per cent. chromium steel is not resistant:—

Reagent.	14% chromium steel, machinable condition.	18% chromium, 8% nickel steel.
Phosphoric acid—		
5 per cent.	Attacked ..	Unaffected
25 per cent. } 2 days 15° C.	Ditto ..	Ditto
50 per cent. } 2 days 15° C.	Ditto ..	Ditto
75 per cent. } 2 days 15° C.	Ditto ..	Ditto
Acetic acid—		
6.6 per cent. } 7 days 15° C.	Ditto ..	Ditto
16.5 per cent. } 7 days 15° C.	Ditto ..	Ditto
33.0 per cent. } 7 days 15° C.	Ditto ..	Ditto
Formic acid—		
5.0 per cent. } 7 days 15° C.	Ditto ..	Ditto
50.0 per cent. } 7 days 15° C.	Ditto ..	Ditto
Conc. } 7 days 15° C.	Ditto ..	Ditto
Tartaric acid—		
5 per cent. } 28 days 15° C.	Ditto ..	Ditto
25 per cent. } 28 days 15° C.	Ditto ..	Ditto
Citric acid—		
4 per cent. } 24 hours 15° C.	Ditto ..	Ditto
6 per cent. } 24 hours 15° C.	Ditto ..	Ditto
10 per cent. } 24 hours 15° C.	Ditto ..	Ditto
B.P. lactic acid, 7 days 15° C.	Ditto ..	Ditto
Calcium chloride—		
10 per cent.	Ditto ..	Ditto
20 per cent. } 14 days 15° C.	Ditto ..	Ditto
30 per cent. } 14 days 15° C.	Ditto ..	Ditto
50 per cent. } 14 days 15° C.	Ditto ..	Ditto
70 per cent. } 14 days 15° C.	Ditto ..	Ditto
Ammonium sulphate saturated, 28 days 15° C.	Ditto ..	Ditto
Sodium sulphate saturated, 7 days 15° C.	Ditto ..	Ditto
Sea water, partial immersion	Slightly attacked	Ditto
2 per cent. iodine solution	Attacked ..	Ditto

The author then proceeded to discuss the interesting fact that the modification in the composition of the steels which led to improved corrosion resistance, also conferred upon them a resistance to oxidation, coupled with increased strength, at high temperatures.

The discussion which followed showed that the subject of stainless steel is one of absorbing interest to engineers. Many questions were asked, and at the conclusion a resolution was carried unanimously that the Council of the Institution be recommended to reprint the paper in the "Proceedings."

SIXTY YEARS AGO.

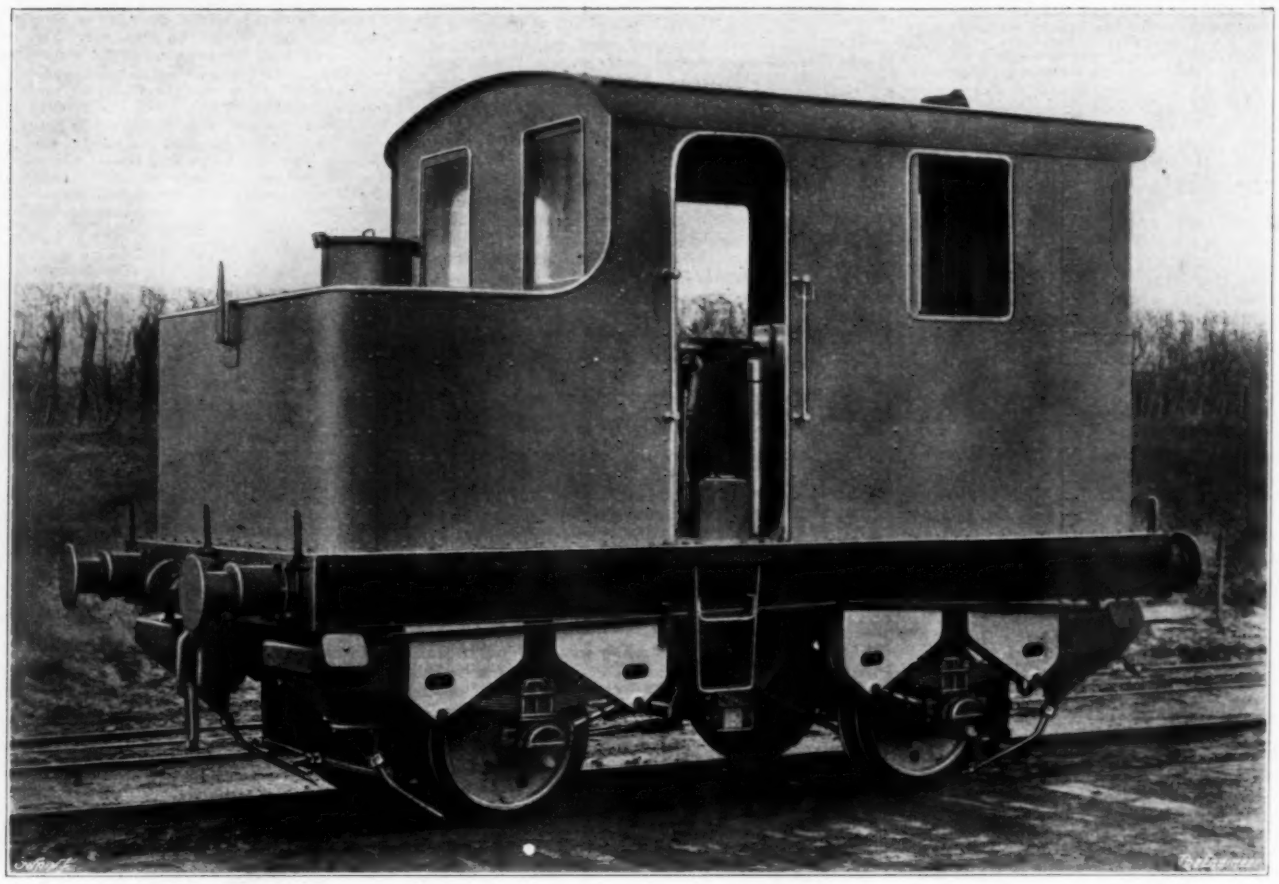
It is commonly held, even to-day, that cannel coal derives its name from the alleged fact that it burns with a bright flame like a candle. If, however, a note published in our issue of April 14th, 1865, can be accepted as trustworthy, it would appear that the real origin of the name is to be found in quite another direction. About the middle of the eighteenth century, according to our note, the celebrated and enterprising Duke of Bridgewater owned a large estate at Worsley, 7 miles from Manchester. The estate contained valuable seams of coal, which were easily reached, but were comparatively valueless by reason of the difficulty and expense of transporting the coal to market. In order to exploit the mineral, the Duke engaged the services of the self-instructed genius James Brindley, who constructed a canal between Liverpool, Manchester, Worsley and the Wigan district. This canal was finished about 1766, and store houses were built at various points along its course, where the duke's coal was deposited for the purpose of supplying the immediate neighbourhood. At that time an artificial watercourse was, in Lancashire and Cheshire generally, designated a "kennel" or "kannel." The name, it may be remarked, still survives in Scotland and elsewhere, as applied to the gutter or watercourse of a street. Brindley himself, it seems, refers in some of his letters to the Bridgewater Canal as "the Duke's Kennel," while the geologist Werner, visiting the English coalfields shortly after the period in question, applied the term "kennelkohle" to the Wigan coal. It would seem, therefore, that cannel coal really means kennel-borne coal. It was pointed out in our note that the application of such a name to the Wigan mineral would be very appropriate at Liverpool, where sea-borne coal from Whitehaven had long been in use, which coal differed in many of its qualities from the duke's coal. Our note concluded with the statement that the assertion that slips of cannel coal would burn like a candle was altogether fabulous.

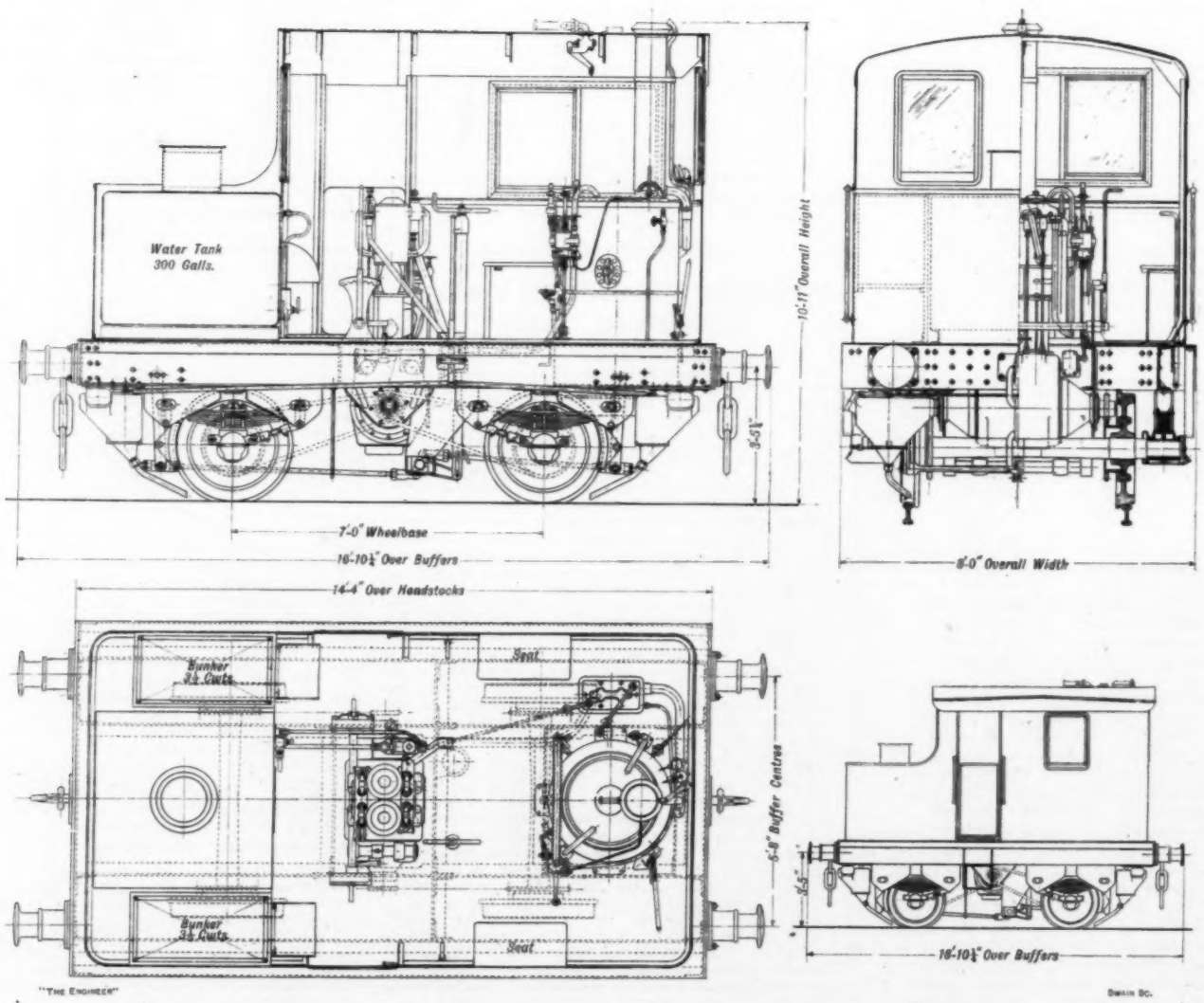
A Reuter's message states that on the occasion of the British railway centenary celebrations a number of Florentine railwaymen have offered to present their British colleagues with a bronze plaque in memory of George Stephenson. The gift will be presented at the forthcoming International Railway Congress in London by a special committee headed by the Minister for Communications in the name of Italian railwaymen.

GEARED SHUNTING LOCOMOTIVE

THE SENTINEL WAGON WORKS, LTD., SHREWSBURY, ENGINEERS

(*For description see opposite page*)





"The Engineer" Swain Sc.

A Geared Shunting Locomotive.

A STEAM shunting locomotive of exceptional interest, of which we give several illustrations on page 436, and herewith, has recently been put to work on the Crewe sidings of the London, Midland and Scottish Railway. It has been supplied by the Sentinel Wagon Works, of Shrewsbury, and the characteristic feature is the adoption of a high-speed enclosed engine connected with the driving wheels by chains. Geared locomotives are not, of course, a novelty, but it appears to us that the idea has been developed with unusual skill in the engine under review.

The locomotive, of which a general view and drawings are given on page 432, weighs 17 tons, but before going on to describe its arrangement, it may be of interest to indicate what it can do, and for that purpose we reproduce in Fig. 1 the result of a test carried out by Captain H. P. M. Beames, Mechanical Engineer, London, Midland and Scottish Railway. These trials were made at Crewe with a dynamometer car and various weights of train behind the locomotive. Records of speed and draw-bar pull were taken for several trips over a run about 1¼ mile long. One of the graphs—that for trip No. 2—made by the instruments are reproduced in Fig. 1, a profile of the most arduous part of the line being superimposed on the record in correct relation to the graph.

For the first trip the train was made up of five wagons and the dynamometer car, and weighed just over 100 tons. The draw-bar pull at starting was 2¾ tons, at 1000 yards the speed was 15 miles per hour, and on reaching the summit, after a stiff climb, the speed dropped to 8 miles per hour. The second and third tests were made over the same route, and a maximum starting pull of 4¼ tons was registered, with 200¼ tons behind the draw-bar; but this was produced when the engine had a late cut-off, whereas in the first trip an early cut-off was maintained throughout the run. For trip No. 4 the load was reduced to 156½ tons, and the summit was passed at a speed of 7 miles per hour. The fifth and sixth trials were made on a much steeper gradient, in which the maximum rise was 1 in 45, and with the dynamometer car, weighing 36 tons, alone in tow. The draw-bar pull at starting was in this case 4 tons, and the maximum speed obtained in 150 yards was 16 miles per hour. Starting on the 1 in 45 gradient, test No. 6 gave a draw-bar pull of 3¾ tons and a speed of 7 miles per hour in 40 yards.

To engineers familiar only with the orthodox type of locomotive, some of these results will appear to be almost incredible. That is to say, an engine weighing 17 tons and producing a pull of 4¼ tons, or, in other words, having an effective adhesion on plain rails of 25 per cent. of its weight, is quite beyond general practice; but it must be borne in mind that the driving conditions in the two cases are very dissimilar.

In the normal locomotive there is a very wide fluctuation in the torque given to the driving wheels by the engine at every revolution, and if the engine is powerful enough to start the load with the cranks approaching the dead centres, at half-stroke it will make the wheels slip and the adhesion will be lost. With the high-speed engine geared down to the driving wheels, however, the variation in torque is minimised, and is spread out round each revolution of the wheels, while the inertia of the wheels themselves has an accentuated effect in reducing the liability to slip. The makers claim, in fact, that the tendency towards slipping is reduced to one-twenty-seventh of the normal value. The result is that the engine gets its load under way steadily without the driver having to juggle with the regulator to check the wheels slipping.

Turning now to the mechanism of the locomotive, it will be seen from the general arrangement drawing that it is built up on a simple framing of 12in. by 4in. joists, which are bolted together through massive blocks of cast iron that serve the double purpose of strengthening the structure and providing the necessary weight for adhesion. The driving wheels are mounted on springs without horn plates—as they are not subjected to the direct side thrust of a crank and connecting-rod—but are controlled by short radius rods.

Symmetrically disposed between the two axles there is the engine itself, of which we give sectional drawings in Fig. 2, while the engraving—Fig. 5, page 436—shows its exterior appearance. It is similar to that fitted in the "Super Sentinel" steam wagon, made by the same firm, except that it is vertical instead of horizontal. It has two double-acting high-pressure cylinders, 6½in. bore by 9in. stroke, and when supplied with steam at 275 lb. per square inch, superheated to 600 deg. Fah., will develop 103 brake horse-power when running at 400 revolutions per minute.

As will be seen from Fig. 2, steam is admitted to the cylinder and exhausted by poppet valves operated by cam shafts in the crank casing, much after the fashion of a petrol engine. The arrangement has the advantages that the cut-off can be effected abruptly, without any appreciable wire-drawing, the incoming steam is not cooled by passing through the same port as that through which the exhaust has just escaped, and the valves can be easily kept steam-tight. The engraving—Fig. 2—shows plainly the method of securing the valve covers, so that they can be quickly removed when it is desired to get at the valves.

The crosshead and guides are of tubular form, and between them and the main stuffing-boxes there are auxiliary stuffings to prevent any condensed steam that may dribble down the piston-rods from finding its way into the crank case and forming an emulsion with the oil.

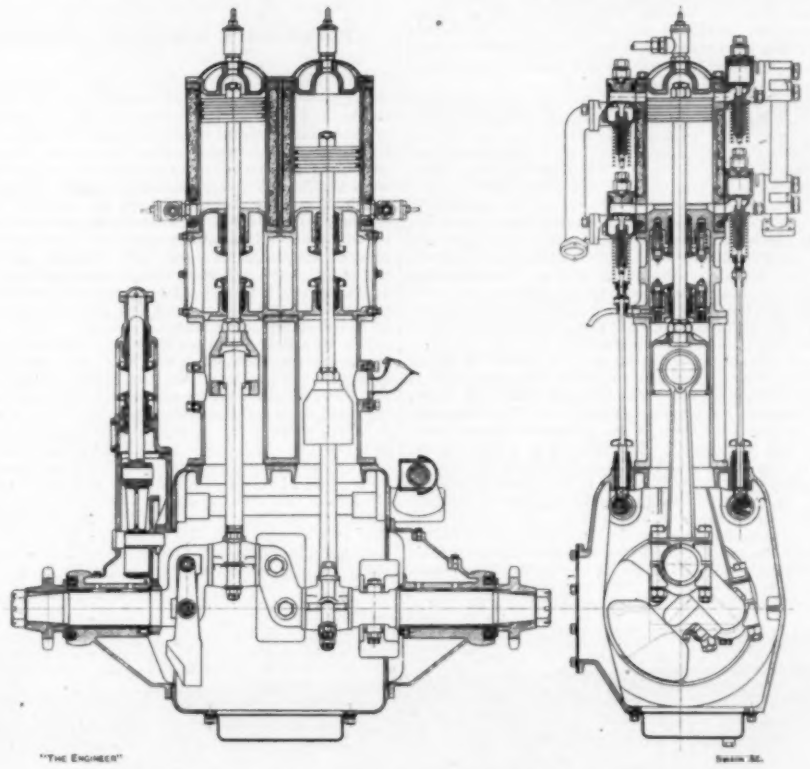


FIG. 2—LONGITUDINAL AND CROSS SECTIONS OF ENGINE

The feed pump, on the left in both Figs. 3 & 5, is similarly equipped, and is driven by an excentric on the gear wheel used to work the cam shafts. It consequently runs at half the engine speed, with a corresponding reduction of trouble through cavitation and slip. The pump naturally runs continuously, and any water it delivers that is not required to meet the load on the engine is by-passed back to the tank. It will be noticed that the main bearings are

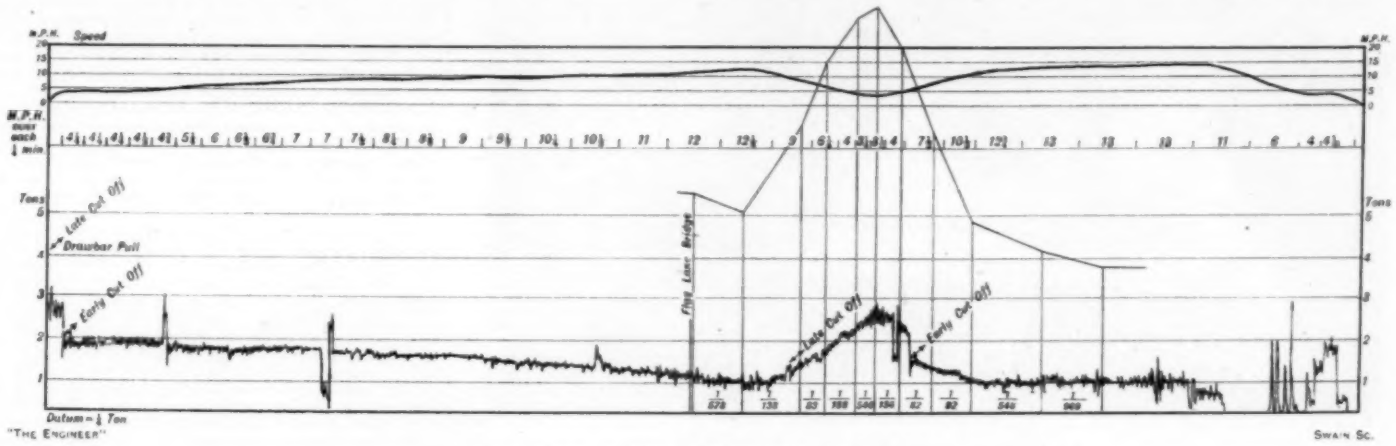


FIG. 1—GRAPH SHOWING RESULTS OF TRIP NO. 2

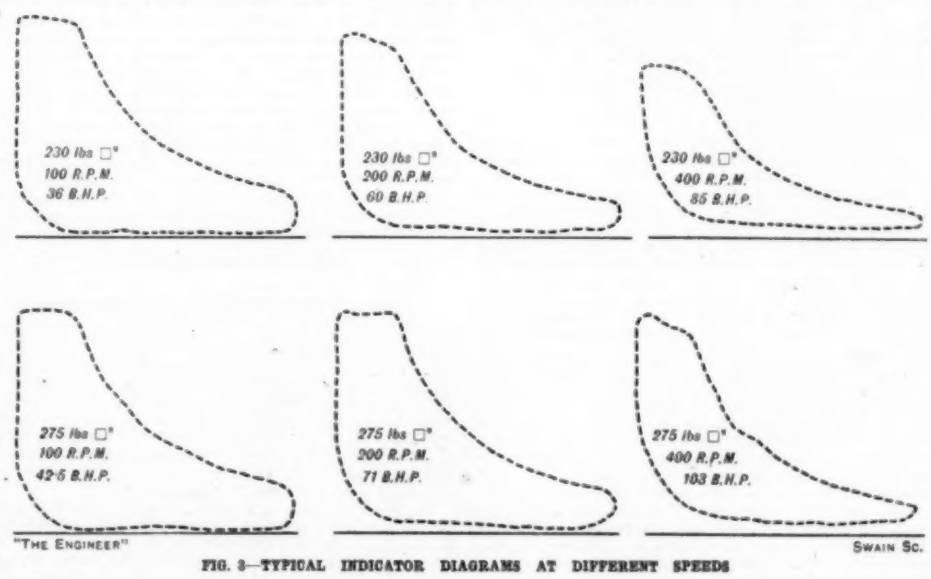


FIG. 3—TYPICAL INDICATOR DIAGRAMS AT DIFFERENT SPEEDS

unusually long, and that the crank shaft is very substantial. The greater part of the lubrication is effected by the splashing of the big ends in the crank case, but a small amount of oil is also delivered by a force pump to the main throttle, and is carried into the cylinders by the steam.

The engine can be worked with the cut-off at either 80 or 30 per cent. of the stroke, and the change is effected by moving the cam shaft endways. The excellent steam distribution obtained may be judged from the indicator diagrams which we reproduce in Fig. 3.

On either end of the crank shaft there is a thirteen-toothed sprocket wheel, and two 1¼in. pitch Renold roller chains connect these wheels with others on the driving axles. The general arrangement of this transmission gear is quite plainly shown in Fig. 4. The axle sprockets have twenty-nine teeth, so that the gear has a ratio of 1 to 2.23. It will be noticed that each driving axle has two sprockets, but only one is in use at a time, the other being provided to take up the work when the first is worn out. The pair of sprockets will, we are told, outlast from eight to ten chains, while the life of the chains themselves should be very considerable, as similar sets working under the much more severe conditions of road traffic will last for anything between 15,000 and 40,000 miles. The tension of the chains is, of course, adjusted by the radius bars.

Steam for the engine is supplied by a boiler in which the firm's practice with steam wagons is followed, for it is of the cross-tube type, with the tubes set at a steep angle, so that a vigorous circulation is promoted. The tubes are arranged tangentially with a space in the centre down which the fuel is dropped. The fire-box is bolted to the shell at the top and bottom by flanged joints, and can be taken out bodily downwards when it is necessary to scale the tubes. In view of the fact that all the tubes are straight a good job can be made of the scaling. A superheating coil is provided in the top of the fire-box, and the two halves of the grate are hinged, so that ashes and clinker can be dumped. With good fuel this boiler is capable of evaporating 1700 lb. of water an hour, and steam can be raised from cold in about forty minutes.

FIG. 4—CHAIN TRANSMISSION GEAR

The driving controls—see Figs. 6, 7, and 8, on page 436—are very simple, and so arranged that the driver can lean out of either side window with the regulator still in reach. The reversing lever has only four positions; that is to say, two cut-offs ahead and astern. There is also a pedal by means of which the steam pipe can be opened to atmosphere, the boiler being isolated at the same time. Then, with the engine in reverse, it can be used as a very powerful brake by acting as an air compressor.

Gravity sanding gear is provided for all four wheels, and generally the equipment of the engine is according to standard railway practice.

Apart from the merit of having the great starting effort already mentioned, these engines have the advantage of economy in working. One man can easily attend to the running and driving, while steam can be got up to pressure so quickly in the morning that overtime charges are reduced to a minimum. It will also be appreciated that the scaling of one of these boilers is a small matter as compared with the work on a locomotive boiler. Retubing is very seldom necessary, as the ends of the tubes are not exposed to the fire. In this connection, it is noteworthy that all the parts of the engine and boiler are interchangeable with those of the steam wagon, and consequently can be procured at very short notice.

In coal consumption there is also a great economy, as the engine only requires 17 lb. of steam per brake horse-power per hour, when on full load, and the boiler will generate about 9 lb. of steam per pound of coal. The economy effected in this direction may be judged by comparing the performance of some ordinary shunting engines before and after they had been converted for Sentinel engines. Before they were altered the coal consumption was about 25 cwt. a day, but after the Sentinel engines and boilers had been fitted, only 8 cwt. of coal were needed for the same work.

These locomotives are being made in three standard sizes of 10, 15 and 20 tons, with maximum speeds of 40, 25 and 18 miles per hour respectively. The engine is the same in each case, but the gear ratio is altered to suit the load.

RIGHTING A SCUTTLED DESTROYER.

From time to time we have referred to the interesting salvage operations which are being carried on by Cox and Danks, Ltd., of 168, Regent-street, London, at Scapa Flow, in connection with the raising of the scuttled German Fleet. In our issue of January 2nd a view of the floating winch gear used for lifting the destroyers was reproduced. A large number of destroyers have already been raised and beached, but they rested in a vertical position on the sea bottom. Early this year examination of the sunken vessels showed that about seven of the destroyers were lying on their sides in about 60ft. of water. At the end of last month the interesting operation of righting destroyer S 136 was carried out in the remarkably short time of six hours, and some account of the method employed may be of interest to our readers.

The two docks used for lifting the ships are, it will be recalled, each 200ft. long and 80ft. wide, and they draw a depth of about 10ft. On the upper part of each dock ten 10-ton hand winches are about 20ft. apart, and are provided with 100-ton pulley blocks, which are attached to lifting wires of 9in. circular diameter. For righting the ship the two docks were moved over the sunken vessel, and by the assistance of divers the ten ropes from one dock were passed beneath the hull and attached to the pulley blocks on the other dock, so that the ship rested in a cradle of ten lifting wires. All that was done to right the ship was to first take the weight to the extent of about half the ship's tonnage—370 tons—and then pay out the ropes on one set of winches and take in on the other winches. On the paying-out side the sheaves of the blocks were about 20ft. apart at the start, and 36ft. when the ship was righted. The friction between the lifting ropes and the skin of the ship was enough to bring the vessel gradually to the vertical within the short space of six hours without parbuckling of any kind. It may be noted that there was sufficient depth of water to allow the bridge, funnels and masts to pass under the dock as the ship gradually assumed the vertical position. Preparations were begun on Thursday evening, March 27th, and work actually commenced on the following day and was suspended on Saturday and Sunday. The ship was righted on Wednesday, April 1st, and was later raised and towed and landed in Mill Bay on Friday, the 3rd inst. Six more sunken destroyers will be similarly righted before lifting, and during the year it is hoped to raise in all some eighteen destroyers.

ROYAL METEOROLOGICAL SOCIETY.

The seventy-fifth anniversary of the foundation of the Society will occur on April 3rd, 1925, and the following arrangements for celebrating the event have been made:—On Tuesday, April 21st, at 3 p.m., a visit will be paid to Kew Observatory, Old Deer Park at Richmond. In the evening at 8 p.m. a conversazione will be held in the rooms of the Society, 49, Cromwell-road, near South Kensington Station (Underground) where there will be an exhibition of photographs, diagrams, instruments, &c.

On the Wednesday at 3 p.m. a commemoration meeting will be held and a welcome extended to honorary members, and a popular lecture delivered by Professor E. van Everdingen, honorary member, Director of the Royal Netherlands Meteorological Institute, president of the International Meteorological Committee. At 8 p.m. a dinner will be held at the Hotel Rembrandt, Thurloe-place, South Kensington.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

ROLLER BEARINGS FOR HEAVY LOADS.

Sir,—I regret the delay in replying to the editorial in your issue of February 27th, but have refrained from referring to it until my complete reply to the discussion before the Institution of Mechanical Engineers had been dealt with.

From the statements made in your editorial I think it possible for those interested to obtain an erroneous impression as to the exact facts, as it appeared to imply indirectly, even after consideration of the full data set out in the paper, that the use of roller bearings was still a doubtful proposition.

In view of the fact that roller bearings have given unqualified satisfaction on machines performing widely varying duties in general engineering and also on the heavy types of machines referred to in the paper over a period of years, it would be unfortunate for engineers if such an impression became general. Apart, therefore, from the practical evidence which is available and which is usually more satisfying to the engineer than theory alone, the following comments on the points raised will, I hope, be of assistance in clearing up some of the doubts.

It is said to be inferred that ball bearings can be designed to support repeated loading with some assurance that ultimate failure by fatigue will not occur, but that with roller bearings the position is different and that no guarantee can be given that the applied stresses on roller bearings fall below the fatigue limit. If this impression can be obtained from my paper, it was quite unintentional, and I think there is hardly any need to go into details, as it would be impossible to cover it satisfactorily in a short letter, and in any case a great amount of data has already been published, which clearly indicates the value of the two types from a fatigue point of view, and I am, of course, here referring to the fatigue of the bearing as a whole.

The whole object of using a roller bearing rather than a ball bearing in some applications is to obtain increased contacting areas and consequently reduce the stresses at these areas, and from the practical side at any rate the difficulties in the past have been chiefly concerned with the design so as to perfect the bearing and make it function in service in such a way as to be comparable with what may be expected from theory. That this result has been achieved engineers familiar with both ball and roller bearings will no doubt agree, and the types of roller bearings referred to in my paper are simply a development of the principle, which has proved that they carry us a long step nearer perfection.

The references to fatigue in the paper all related to fatigue tests of complete bearings, and the whole story of how these tests were carried out and the results arrived at were given before the Institution of Automobile Engineers, as mentioned in the paper. Consequently I felt it was unnecessary again to cover that ground. It may not be out of place here, however, to state again that such research has given us a definite basis on which to arrive at conclusions regarding the length of life of a bearing under definite loading conditions, and this is surely comparable with what is done in other fields of engineering.

In dealing with structures or machines the designer always employs a factor of safety or, as some engineers term it, a factor of ignorance, to cover the various characteristics which cannot be definitely known, and the value of this factor of safety is greater or less, depending on whether the designer requires a cheap machine, which may be to some extent unreliable, or an expensive machine, which may be perfectly safe. Exactly the same problem presents itself to the anti-friction bearing engineer, although perhaps less latitude is allowed than in dealing with the materials for normal mechanisms or structures. If the engineer can tell us definitely the exact values of the loads coming on a given bearing, the number of hours that the load will be applied, and the effects of shock load which may be expected, then we can state just as definitely how many hours he may expect a particular bearing of either the ball or roller type to give satisfactory service, that is, for the bearings referred to in my paper.

As I have perhaps already trespassed too much on your valuable space, I would only add that the other points raised in your editorial are fully dealt with in the reply to the discussion on the paper, and it is hoped that these further notes on what is perhaps the most important point raised will have the effect of at least inspiring some confidence in units which the modern engineer has found to be of considerable service in the development of machine design.

The Skefko Ball Bearing Company, Ltd.,
J. B. Dahlerus,
Luton, April 8th. Managing Director.

THE EFFICIENCY OF AIR COMPRESSORS.

Sir,—I have read with interest your article in The Engineer of March 20th dealing with the efficiency of a Belliss compressor of 1200 c.f. supplied as part of the pneumatic equipment for the Clyde Navigation Trust.

I am writing as one interested in the performance of high-pressure compressors, and referring to the isothermal efficiency of 76 per cent. which is given, I should like to ask Messrs. Belliss and Morcom if they would, for the benefit of engineers interested in compressor problems, state what this isothermal H.P. is based on. Is it the ratio of the isothermal H.P. based on actual air delivered to the indicated horse-power taken from actual indicator cards, or is it on some other basis?

If on the basis indicated, what figure would they give for their overall efficiency, which I generally calculate to be the isothermal H.P. required to compress the number of cubic feet actually delivered per minute over the actual brake horse-power required at the compressor shaft.

I have by me some tests made on a well-known single-stage multi-cylinder compressor having mechanically-operated inlet valves in the form of a ported gudgeon within the single acting pistons.

These tests, carried out by a well-known consulting engineer, give an isothermal efficiency of about 84 per cent. based on the isothermal H.P. on air actually delivered over the indicated air horse-power.

If the 76 per cent. given in your article is on the same basis it would appear that this single stage machine is thermally more efficient than the vertical two-stage, and, for this reason, it would be interesting to know the overall efficiency of the vertical compressor, because this latter takes into consideration all losses, whether thermal or mechanical.

Interested.

London, April 7th.

Railway Matters.

The Ishover Light Railway, which is a mineral line belonging to the Clay Cross Colliery Company, converted to passenger-carrying conditions, was opened for public traffic on the 6th inst.

Owing to ill-health Mr. P. J. Brennan, after a service of forty-seven years, has retired from the position of secretary to the Irish Railway Clearing House. He has been succeeded by Mr. W. E. Richardson.

The Ecuadorian Government has granted permission for the construction of a new railway from Tipococha to Tambo in the Province of Canar, which will provide an outlet for the production of oats, potatoes and wheat grown in these districts.

A conference has been held at the Polish Ministry of Railways concerning the establishment of direct railway communications between Poland and Yugoslavia. The conference was attended by delegates of the Yugoslav and Rumanian railways.

The London, Midland and Scottish Company and the London and North-Eastern Company have withdrawn their separate and competing schemes for railways from Nottingham, through Sherwood Forest to Retford. Both companies are jointly to submit in the next Session a scheme for a commonly-owned railway.

The Great Western Railway Company, very wisely, we think, has appointed a divisional signal and telegraph engineer in the person of Mr. H. F. D. Page, who has been the assistant to the signal engineer since 1923. Mr. Page will have charge of all the signals and telegraphs in South Wales, and have his office at Salisbury-road, Cardiff.

The Southern Railway Company has recently issued a statement which shows that out of 113,709 steam-worked trains run daily, Sundays excepted, during the month of February last, 93 per cent. arrived on time or were not more than 5 minutes late, 5 per cent. were over 5 minutes but less than 10 minutes late, and 2 per cent. were over 10 minutes late.

In a written reply to Mr. Thurtle, Lieutenant-Colonel Moore-Brabazon stated that he did not at present contemplate the introduction of any general legislation with regard to canals. The Government had, however, given assistance, and was still prepared to give assistance, through the Unemployed Grants Committee, to practicable schemes for the improvement of canals.

We regret to hear of the sudden death, after an operation, of Mr. John Davies, who was the general manager of the Midland and South-Western Junction Railway until its absorption by the Great Western. Mr. Davies commenced his railway career on the Cambrian, became general manager of the Central Wales, and was, for a dozen or so years, commissioner of railways for Western Australia.

The death of Mr. Logan G. McPherson is announced and deserves mention in these pages, because of the useful work he inaugurated and carried on in the Bureau of Railway Economics. That was established at the invitation of a committee of the railway executives of the United States, and often have we been under an obligation to the bulletins issued by Mr. McPherson, as his activities frequently covered other spheres than that of the United States.

The usual preliminary statement that precedes the Railway Returns has been issued as a Stationery Office publication in relation to the results of last year's working. The tables show the capital expenditure and receipts, the revenue receipts and expenditure from railway working, the total net receipts, the appropriations of net income and a summarised balance sheet. They also show the number of passengers carried, the tonnage conveyed, the average receipt per ton, and per ton-mile, and the leading operating statistics.

A new corporation, the New York, Pittsburg and Chicago Railway Company, has filed an application with the Interstate Commerce Commission for permission to build 344 miles of track, with a main line 283 miles long, running almost entirely across Pennsylvania, east to west. The company was formed in Pennsylvania in January, and is not associated with any existing railway. The main line will run from Alleghany to Easton, with a 30-mile branch at Pittsburg Junction and a 31-mile branch at Brush Run. The object is to furnish a direct low-grade line from New York Harbour to the West, *viâ* Pittsburg.

Further railway facilities are about to be provided at Madrid, where two of the principal stations, Del Norte and Del Mediodia (or de Atocha), situated on opposite sides of the city, are to be connected by a subway, which, when completed, will enable a direct service of through trains to be made from the Mediterranean to the Atlantic. The subway will be laid with a three-track standard-gauge line, by which both passenger and goods cars can be transferred from one station to the other. A belt-line will be constructed similar to that encircling Paris. A direct goods service to the public markets at Mostenses and Carmen will be provided.

According to the Board of Trade returns the value of the railway material exported during the first two months of the present year was as follows, the corresponding figures for 1924 and 1923 being added in brackets:—Locomotives, £561,131 (£401,667, £615,435); rails, £371,156 (£438,153, £341,071); carriages, £346,849 (226,121 £272,581); wagons, £531,181 (£643,906, £419,979); wheels and axles, £117,986 (£125,393, £113,501); tires and axles, £83,787 (£133,394, £64,698); chairs and metal sleepers, £60,072 (£264,366, £81,260); miscellaneous permanent way, £245,233 (£268,871, £186,995); total permanent way, £878,234 (£1,230,177, £787,525). The weight of the rails exported was 37,555 tons (46,596 tons, 35,101 tons), and of the chairs and metal sleepers, 4472 tons (20,591 tons, 7400 tons). During the month of February last locomotives were shipped to the following countries to the values named:—India, £45,698; South Africa, £36,032; Australia, £28,532; Ceylon, £17,196; the Argentine, £6646. Rails were exported similarly as follows:—The Argentine, £43,905; New Zealand, £31,276; South Africa, £8074; India, £5976; West Africa, £4731; Portuguese East Africa, £3833.

Notes and Memoranda.

An experimental turbo-generator of 35 kilowatts has been put to work in Sonoma County, California, to test the commercial possibilities of using the natural steam which issues from the ground there. The pressure of the steam is from 60 lb. to 70 lb. per square inch, and its temperature 335 deg. Fah. It is said to be 99 per cent. pure.

According to the *Wireless World*, the British Broadcasting Company has forwarded to the Institute of Patentees, 44, Great Russell-street, W.C. 2, a list of matters connected with wireless apparatus in which improvements are urgently required. Free particulars can be obtained from the Institute, and the assistance of experimenters with scientific knowledge and facilities for research work will be gladly welcomed.

The Department of Posts and Telegraphs in India is investigating the practicability of erecting radio direction-finding stations at certain ports in India. The directional receiver installed at Karachi as an experimental measure has proved successful, and as soon as the reliability of the service is completely proved, a charge of Rs. 5 per bearing is likely to be made. Another experimental receiver is being installed at Butcher Island, Bombay, but it appears that a more suitable site will be found for it.

It is reported in the *Electrical Review* that in order to assist in the traffic control of one of the main roads in Leicester, the superintendent of public lighting, Mr. Thomas Wilkie, acting on the instructions of the Lighting Committee, is erecting a spot-lighting apparatus. The light will be projected from a pole 30ft. high, and the beam focussed on the pointsman on duty. It is hoped by this means to make the pointsman's signals clear to drivers of vehicles and also to pedestrians. The experiment is being closely watched in Leicester, as this installation will be the first of its kind in Britain.

In the course of a paper on the roasting of sulphur ores, read before the Chemical Engineering Group, Mr. J. Harris said that he had been experimenting with a new form of stirring gear having a shaft made of cast steel, which was water and air cooled. The shaft was fitted with a detachable arm, neither water nor air cooled, made of an alloy mainly composed of chromium and iron, which retained its strength at high temperatures in a very marked manner. He had put castings of the alloy to very severe treatment, and had found a solid arm made of the alloy stronger and more efficient than a water-cooled arm made of cast iron.

In connection with the design of light aeroplanes the American Contest Committee of the National Aeronautic Association has made the following statement:—The Committee, after very careful deliberation, have decided to place the engine limits for single-seater light planes at 1310.9 c.c. In view of the fact that development has not progressed far enough the Committee do not feel it desirable to place limits for two-seater light planes, but recommend that 2621.8 c.c. would receive favourable consideration. It will be remembered that at the light plane trials at Lympne last year the engine capacity was limited to 1100 c.c.

It is announced in the Stockholm newspapers that the Swedish mining engineer, M. Rutger von Seth, has obtained patents throughout the world for a method of extracting vanadium from Swedish phosphorus-bearing ores. The method, if exploited in Sweden, will increase the world's production of vanadium by about 100 tons, and has the advantage that it can be applied without any special arrangements at ironworks employing the Thomas method, in which the slag contains vanadium. The inventor estimates that the cost of the production of vanadium by this new method will be only 10 kroner per kilogramme.

In the course of a lecture to the Midland Institute of Mining Engineers, on "Devices to Prevent Overwinding," Mr. W. L. Grassham said that what is required is a device that will control the speed throughout the wind, will not act violently if excessive speed is reached at any point, but will decrease speed to conform with the predetermined speed-distance curve, and so allow the wind to continue. A control device should accomplish this in two ways—by acting on the throttle and not applying the brake; if this is not sufficient, and it becomes necessary to apply the brake, the brake should be applied gradually, and with a gradually increasing pressure.

The explosion which occurred on March 17th in the No. 41 shaft mine of the Bethlehem Mines Corporation, at Barrackville (Marion County), not far from Fairmont, W. Va., and killed the whole of the night shift of thirty-four men, was of a particularly violent nature. According to the *Coal Age*, the explosion travelled through the main winding shaft, causing flames to shoot high in the air, tearing out the guides and buntons, jamming the cages and generally causing a mass of ruins in and about the shaft. The head frame was virtually lifted from its moorings and displaced to the extent that one leg was moved a distance of about 12in. from its original position. The concussion of the explosion completely wrecked the main hoist room, and caused one wall of a brick compressor room at a distance of 40ft. from the edge of the shaft to collapse. Windows of the houses and other buildings within a radius of about 1000ft. were shattered.

On the recommendation of the Electricity Commissioners, a scheme is under review by the Halifax and Huddersfield Corporations for linking up the two electricity undertakings to meet the needs of extensions of supply instead of the proposed extension of the Huddersfield plant. The Commissioners pointed out that Halifax had recently made considerable extensions, and a scheme was submitted for linking up the two undertakings at an estimated cost of £84,000, towards which it was to be expected that assistance would be received from the Unemployment Grants Committee, and that if and when the Joint Electricity Authority for the West Riding (Aire and Calder) District was set up, the responsibility of the balance of the upkeep over capital would be taken over by the joint authority. The Electricity Committees of Halifax and Huddersfield are agreeable to the proposal, and, failing agreement on the question of price for supply by one to the other, it is proposed that the Commissioners should arbitrate.

Miscellanea.

The Manchester Ironmongery Exhibition is to be held from April 21st to 30th.

The New South Wales Government has offered to build a floating dock at Walsh Island.

It is proposed to erect a hydro-electric power plant near Chelsea, on the Gatineau River, Canada, with a capacity of from 50,000 to 70,000 horse-power.

It is proposed to build a new low-level railway bridge across the Niagara River for the New York Central Lines. It will cross from Black Creek to Grand Island and Tonawanda.

It is probable that a company will shortly be formed in Sweden for working the pyrites deposits in Vaesterbotten. An annual output of 200,000 tons has been estimated.

The air service which it is proposed to organise between Kisumu, on Lake Victoria Nyanza, and Khartum, will employ eight passenger seaplanes, which will follow the course of the Nile.

The new coaling staithes at Blyth, which are to be put up by Stothert and Pitt, of Bath, are to be equipped with conveyors of the traverser type, with a range of from 12ft. to 46ft., and a capacity of 500 tons to 800 tons per hour.

Although the Polono-Upper Silesian Iron and Steel Cartell has not been established by April 1st, as intended, negotiations are, according to the *Iron and Coal Trades' Review*, being continued towards its formation, with every prospect of success.

A large power plant is to be put up at Glacier Bay, on the Portland Canal, just below the Salmon River on the Alaskan-Canadian border. It will be some 150 miles north of Prince Rupert, and will cost somewhere about 1,500,000 dollars.

For the fourth time in succession, the *Commercial Motor* Cup was won by a team of Thornycroft wagons at the recent, nineteenth, annual parade of the Commercial Motor Users' Association, held in Lincoln's Inn Fields. The vehicles are owned by the Shell-Mex Company.

With the construction during this summer of wireless stations at Aklava, at the mouth of the Mackenzie River, and at Fort Smith, in the Mackenzie River basin, the system of communications for the north-western section of the North-West Territories of Canada will be complete. The next station to be erected will be on the western shores of Hudson Bay.

A new fire float is being built for the Hong Kong Government by the Hong Kong and Whampoa Dock Company. She is 101ft. long by 23ft. beam and 9ft. 6in. deep. The steam machinery is to give her a speed of 10 knots and the Merryweather fire pump will have a capacity of 4000 gallons a minute, at a delivery pressure of 150 lb. per square inch.

A bridge is being built across the Second Narrows of Burrard Inlet, British Colombia, to carry a railway track and roadway. It will be 635ft. long, with an opening span of 185ft. Some difficulty is being experienced in getting in the pier foundations, as the tide runs at some 6 knots, and has a range of 13ft., but the bridge is to be completed by next September.

What it is said will constitute a record in long-distance ocean towing has just been started at Adelaide. The steamer City of Singapore, which was badly damaged by fire and explosion about a year ago, has been taken in tow by two Dutch tugs, with the idea of taking her to Rotterdam to be rebuilt. The distance is 13,000 miles, and the voyage will probably take four months.

A new route was started by the Pekin Tramcar Company in January from Hsi-ssu-pai-lou to Tung-ssu-pai-lou. This is the third route to be opened, the first being from Hsi-ssu-pai-lou to Chien-men, which was started on December 17th, 1924, and the second from Tung-ssu-pai-lou to Chienmen, started on January 1st this year. The company reports good business, almost all cars being crowded to capacity.

The Planning Committee of the Russian National Commissariat for Agriculture has approved a scheme submitted by an electrical company for rural construction in connection with electric ploughing. The company possesses twenty electric ploughing sets, for the use of ten of which orders have already been received, while an outlay of 72,000 roubles will be necessary to get the other ten sets placed in service.

The Inkerman Bridge over the Burdekin River, Queensland, an important link in the Great North Coast railway chain, once more has succumbed to flood, according to the *Industrial Australian*. To avoid damage by *débris* brought down by the almost annual floods, it was built at a very low level, so that by the time the logs began to float down the bridge would be sufficiently submerged to be beyond the reach of damage. This anticipation, however, has not been realised, and the bridge has just been partly wrecked for the third time in its short history. This means serious inconvenience in carrying on the northern railway traffic, as it must be several weeks before the bridge is capable of carrying trains across the Burdekin, and in the meantime passengers and goods must be ferried over.

The completion of the Burrard Drydock Company's floating dock and workshops and their operation, has been delayed very seriously, according to the *Canadian Engineer*, by the Dominion Government regulations regarding the importation of goods packed in straw. The Dominion Department of Animal Health recently issued orders that in all cases goods that came packed in straw, which were not accompanied by certificates of purity from danger of foot-and-mouth disease, must be sent back to the shippers. Electrical equipment for a 75-ton crane for the Burrard Drydock Company arrived on the ss. Canadian Transporter a few weeks ago, and was found packed in straw, and with no certificate of health. It was ordered back to the shippers. The company has exhausted every appeal, and has been informed that it can do nothing but obey the law. The machinery must go back, be repacked and reshipped.

GEARED SHUNTING LOCOMOTIVE

THE SENTINEL WAGON WORKS, LTD., SHREWSBURY, ENGINEERS

(*For description see page* 433)

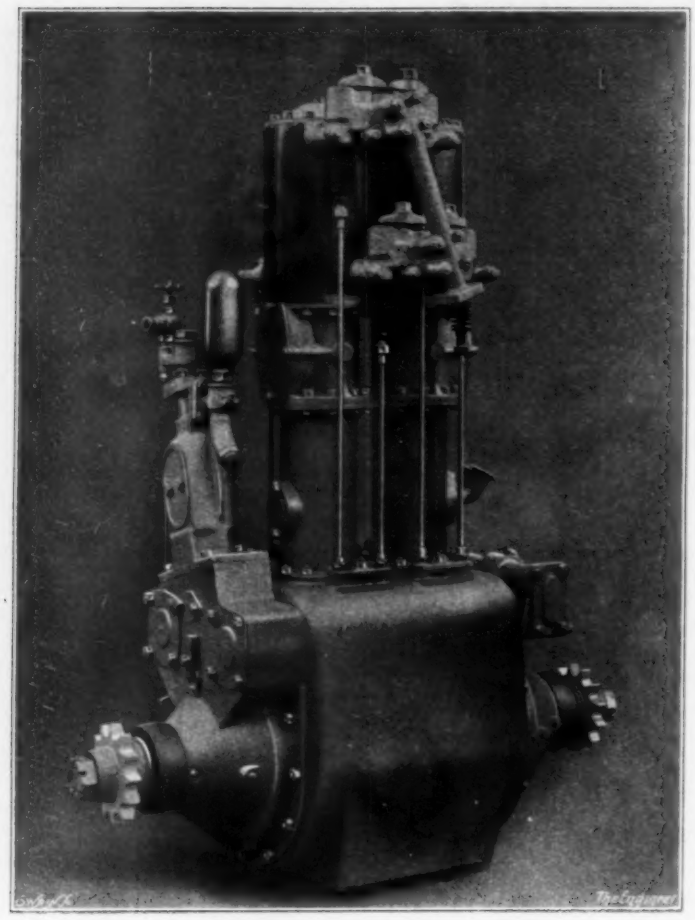


FIG. 5

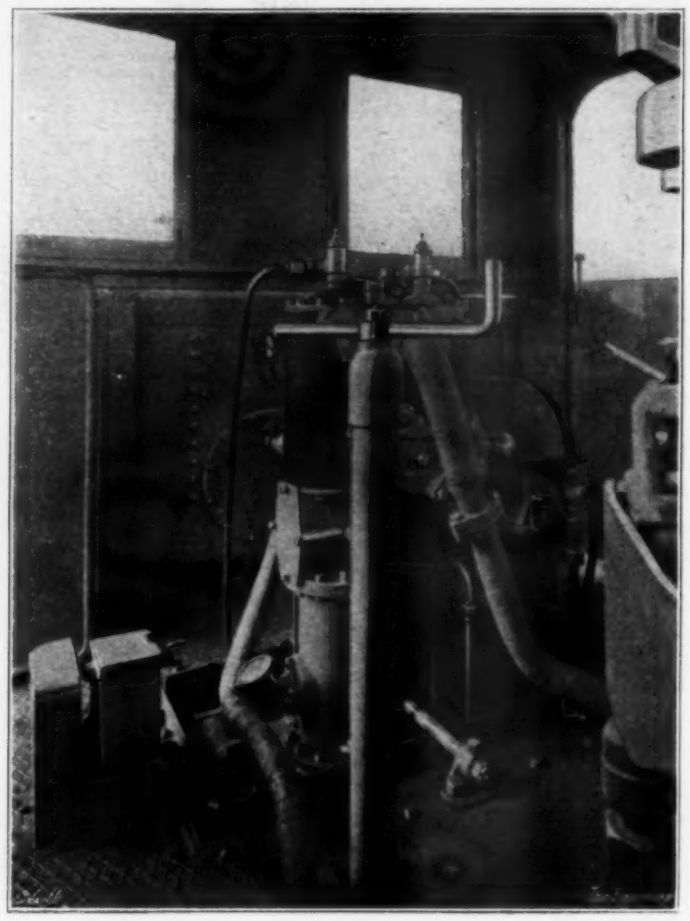


FIG. 6

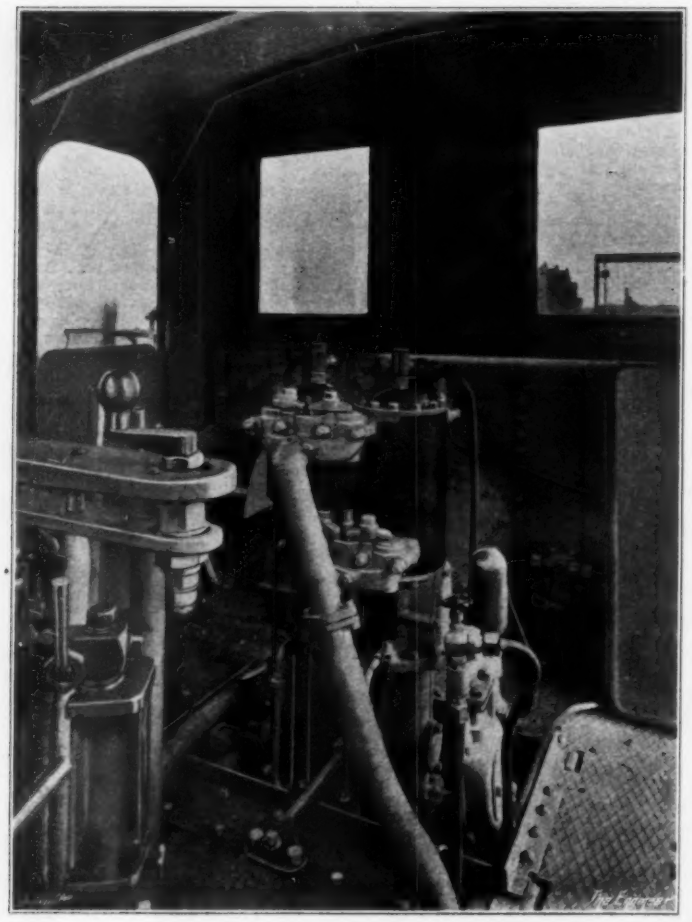


FIG. 7

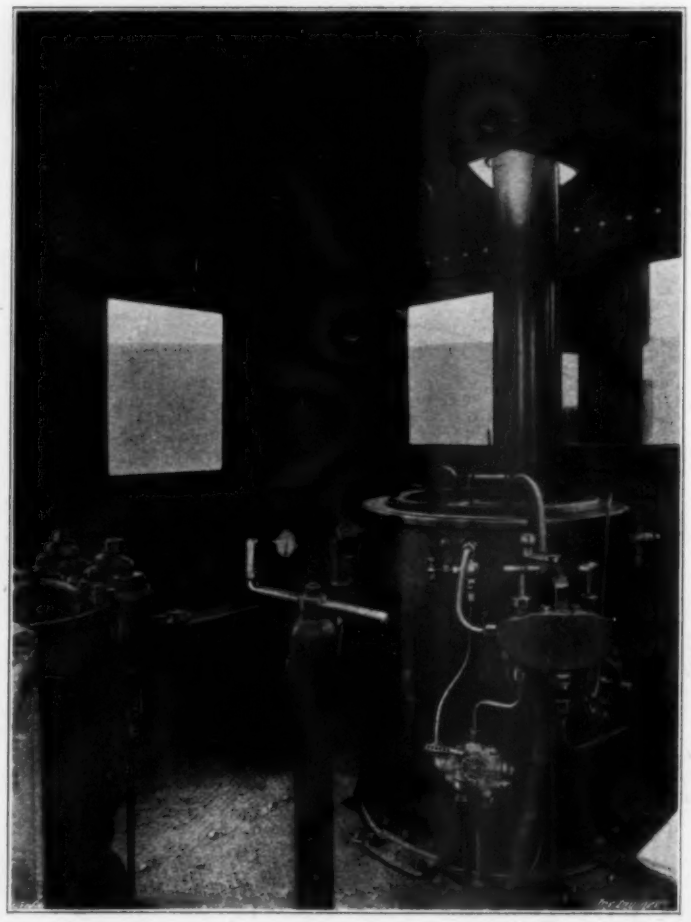


FIG. 8

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Contents.

The Engineer, April 17th, 1925.	PAGE
A Seven-day Journal	423
The British Steam Railway Locomotive from 1825 to 1924. No. XVI. (Illus.)	424
The Mechanical Equivalent of Heat: Joule's First Measurements. (Illus.)	426
Shifting a Bridge in Vienna. (Illus.)	428
Institution of Naval Architects. No. III.	429
Recent Developments in Corrosion Resisting Steels	431
Sixty Years Ago	431
A Geared Shunting Locomotive. (Illus.)	433
Righting a Scuttled Destroyer	434
Royal Meteorological Society	434
Letters to the Editor—	
Roller Bearings for Heavy Loads	434
The Efficiency of Air Compressors	434
Railway Matters	435
Notes and Memoranda	435
Miscellanea	435
Leading Articles—	
Some Aspects of Education	437
The Time Element	438
Literature	438
Water Power Resources of Canada	439
An Old Stockton and Darlington Railway Locomotive. (Illus.)	440
Constant Current Motors. (Illus.)	440
Government Tests of Agricultural Machinery	440
New Type of Road Sweeper, Sprinkler and Collector. (Illus.)	441
Local Reflection of Wireless Waves from the Upper Atmosphere	441
A New Pneumatic Drill. (Illus.)	442
The Punjab Hydro-electric Scheme	442
Travelling Steam Crane. (Illus.)	443
Platinum Boom in South Africa	443
Educational Intelligence	443
Increasing the Efficiency of the Screw Propeller. (Illus.)	444
Provincial Letters—	
The Midlands and Staffordshire	445
Lancashire	445
Sheffield	446
North of England	446
Scotland	446
Wales and Adjoining Counties	447
Personal and Business Announcements	447
Contracts	447
Catalogues	447
Current Prices for Metals and Fuels	448
French Engineering Notes	449
British Patent Specifications. (Illus.)	449
Forthcoming Engagements	450

THE ENGINEER.

APRIL 17, 1925.

Some Aspects of Education.

At the annual meetings of the Association of Technical Institutions on Friday and Saturday, March 6th and 7th, it was resolved that a conference should be called to consider the relationship between technical education and industries. We may assume from a knowledge of the constitution of the Association and from consideration of some of the speeches and papers that the schools in the mind of the Association were those that are fed from the primary and secondary schools directly administered by the Board of Education, and not the more scientific colleges and universities. Possibly we might differentiate broadly between the two by describing one as technological and the other as technical, the former teaching more technology and craftsmanship than science, the latter more science than technology. The boundary is ill-defined and fortunately in this connection is of relatively little importance. The important thing is that the Association recognises that the time has come when the position of technical education ought to be reviewed. We are very heartily in accord with that view, and trust that whilst the Association is paying attention to that class of education in which it is mainly interested, the position of the technical education and training of those engineers who follow a rather more scientific course, as affected by the progress of engineering since the last conference was held, now some fourteen years ago, will not be forgotten.

In the course of recent inquiries we have noticed with the greatest pleasure the growth of the belief that technical and scientific education must do more for the student than merely provide him with the tools of his vocation. There are even, we are glad to say, those who hold that a scientific education may be as "liberal" as the classical education of our grandfathers, that it may open and broaden the mind and add that refinement of feeling without which education can never become cultivation. It is on that aspect of the subject that we desire to place a few ideas before our readers to-day. Several hours of leisure have already been added to the week, and in succeeding years the hours of work will grow less and less, and the hours when men have to employ themselves will increase. Whilst the manner in which the working hours are used will affect the material welfare of the nation, the employment of the leisure hours, the hours outside the factory and office, will affect the intellectual development and the contentment of the people. There was a time when employers boasted of living for their work alone, and when the men, willy-nilly, had no time to think of anything else. We have heard it said by experienced works managers that shops were happier in those days. Their work meant more to the men. It was not merely an incident in the twenty-four hours; they went to bed with it, they woke up with it, they thought of little else, and talked of little else. It filled their lives and, generally speaking, a full life is a happy life. Clearly, such a view has its limitations. The mechanic proud of his handicraft, the machinist rejoicing in his skill and in his knowledge of the characteristics of the tool he operated, even the labourer "upon the floor" who might be called upon at any moment to exercise his ingenuity, might find a relish in an existence spent wholly in work; but there are crafts less enviable than these crafts in which work is physical drudgery, dull soul-breaking routine from which the worst-spent leisure is a longed-for relief. It is to be feared that in engineering we have added to the latter. Manual skill is now reserved for the few, whilst for the many labour is a long monotony of repetition. Natural progress, on the one hand, and trade union demarcation on the other, have between them prevented that self-expression which gave interest to labour. It is not surprising, therefore, that men look ever towards the reduction of hours and turn their minds to occupations which will give some outlet to their workshop-stunted personalities. Whilst this motion is taking place amongst the men themselves, it involves those immediately above them, the charge hands and foremen, and spreads even, in many cases, to the managers and directors. Work shorter hours in the shops and sooner or later shorter hours will be worked in the offices. This course, as we have suggested, is not wholly to be deprecated. The man who thinks of nothing but his immediate work is generally a dull dog, unless the work itself happens to be of the broadest nature. But not to think of work and to think of nothing else is worse still. It is for that reason, we say, that the problem of the future is the problem of leisure. For the solution of it, we must turn to education; not vocational education alone, but to some form of education that will broaden our interests, enlarge our imaginations, and bring us into harmony with other men. That kind of education can, we believe, be given in technical colleges if a bold change is effected in curricula. At the present moment the attempt is made to teach too much. The student is required to study intimately too many subjects. What we conceive to be desirable is a very thorough grounding in certain selected subjects, and a broad general knowledge of others. Give the student a thorough grasp of principles, and if he cannot make use of them he will never, with all the teaching of details in the world, shine in his profession. For example, the mechanical engineer should be taught with the greatest completeness the principles of mechanics and machinery, but his knowledge of physics, sound, light and heat—thermo-dynamics excepted—and of electricity and of chemistry need not be so intimate, and should be qualitative rather than quantitative. In these subjects he would probably learn more that would be useful to him from lectures such as Tyndall gave than from class-room work, which requires him to do mathematical exercises in subjects with the principles of which his knowledge is far from intimate. By the employment of some such differentiation, we might succeed in making men with broader interests in science as a whole, whilst assuring ourselves that on a few selected subjects they were more thorough than men now are.

Of course, as ever, the examination is the bane of education. We all know that as a test of real competence it fails hopelessly, and yet because it is so difficult to find any practicable alternative, we have gone on employing it and allowing it to intrude more and more into the training of our youths. As long as it, in its present form, is the test of merit, technical education will remain what it is, and great authorities will have to lament, as one did to us only a few days ago, that not more than five per cent. of all the students were worth the money that had been spent on them. A single good question would be a better test than the half-dozen or more that are now set before the candidate. More could be learned of a student's knowledge and mentality by asking him to "discuss the derivation of the laws of moving bodies" than by a dozen mathematical puzzles; more of the practical value of his mathematical knowledge by a single question on the value of superheat or higher pressures or reheating, than by a score of set exercises. However, such things are details; we may take it that the nature of examinations will change when at length we admit the defects of the present system of technical education, and

recognise that in the future we must make broader, more cultivated, engineers than satisfied the needs of the past.

The Time Element.

We are accustomed to estimate the structural value of our materials, and particularly of metals, by reference to a series of mechanical tests made, generally, as rapidly as possible. On the whole, universal experience justifies our confidence in that method, but sometimes commercial tensile tests are carried out with a rapidity which gives rise to misgiving, for the testing machine may be made to over-run its proper reading before the test piece has, as a matter of mere inertia, had time to respond. That misgiving applies principally to the determination of the breaking load. But apart from these crude, although we fear sometimes intentional, causes of inaccuracy, which do not, of course, apply to carefully made tests carried out for the purpose of studying the true properties of metals, there are some reasons for considering that the influence of the time element is not always sufficiently considered. It is true that in the tensile test and even in fatigue testing by such methods as the Wöhler or the Haigh, the effect of relatively wide variations of speed is small. So long, therefore, as we merely think of ordinary rates of loading, the speed factor need not, perhaps, trouble us except in so far as we have to take into account the very large stresses set up by inertia forces.

When, however, we come to very high speeds, such as occur at times in special types of machinery, or to very long-continued exposure to stress, factors have to be taken into consideration which are not directly related to the results of ordinary mechanical tests. Thinking first of the effects of high rates of loading, we know that when the rate becomes sufficiently high to be classed as "shock," we have to deal with effects upon the material which in some respects are different from those resulting from more gradual application of stress. It has long been known, for instance, that the way in which wrought iron or mild steel will fracture can be appreciably affected by the manner in which it is broken. A notched bar of quite tough material can be made, when broken by a sharp blow, to exhibit a strikingly crystalline fracture, while the same material, broken slowly, shows a fine fibrous fracture. This difference is sometimes ascribed entirely to the effect of the notch, but a few experiments will serve to show that such material breaks when "statically" loaded in a manner quite different from its failure under a blow. The study of the way in which the resulting fracture takes place among the micro-constituents of the steel exhibits the reason of the difference, although apparently the properties of the particular steel determine at what rate of loading the "shock" effect makes itself felt. Similarly in regard to fatigue, there is good reason to believe that although variations in the rate of alternation between a few hundred and even 5000 per minute make no serious difference to the observed fatigue range, yet at much higher speeds marked differences appear. On the high-speed side, therefore, we have reason to give the time element serious consideration, more particularly where exceptionally high speeds of loading are involved. At the other extreme are the cases, far more numerous in present-day practice, where stresses have to be borne continuously or intermittently for very long periods of time. We take it for granted that because it takes a certain load to fracture a piece of steel, therefore such a piece of steel will bear a certain fraction of that load indefinitely. Of course, removal of part of the steel by gradual corrosion or wear is not contemplated in such an assumption and, apart from such deleterious influences the justification of our fundamental assumption is found in experience—steel structures have stood for many years and show no signs of reduced strength or stability. It must be borne in mind, however, that very large factors of safety have been used, particularly in the older structures. With increasing severity of conditions there is an unavoidable tendency to rely more fully on the test strength of our materials, and the question of the effect of long continued stressing becomes increasingly important. It is the more important where special conditions serve to introduce possibilities of gradual change in the materials. The influence of higher temperatures is particularly to be considered, since it has recently been shown that loads quite insufficient to produce immediate fracture in test pieces at elevated temperatures may yet produce serious "creep," which may lead, in practice, not to actual rupture but to seriously injurious deformations. There is, furthermore, the possible influence of various actions of a more or less chemical nature, which, although totally distinct from ordinary corrosion, appear to lessen, in the course of time, the cohesion between the crystal grains of metals. These actions have hitherto made themselves felt to a painful extent only where there have been specially unfavourable conditions, so that some sort of chemical action might have been anticipated. This effect, again, may only be a question of time, although the time involved in more normal circumstances is probably so long that it need not be considered for practical purposes.

It must not be inferred from what we have said that we desire to raise any suspicion as to the safety and permanence of our existing structures. In them the factors of safety are so large and the conditions, as a rule, so favourable, that the guidance of long experience can be entirely relied upon as a guarantee of safety. It is where conditions are more severe, as regards temperature or surroundings, as, for instance, in steam boilers called upon to work at abnormally high temperatures and pressures, or in certain parts of internal combustion engines, that consideration of these factors—at which, as yet, we can do little more than guess—becomes increasingly important. The pioneers of progress in these directions will not, we feel sure, be deterred by considerations of this kind, but they will be wise if they bear them in mind and give due weight to the indications which current investigations afford in regard to the time factor.

Literature.

Reinforced Concrete Bridges. By W. L. Scott, A.M. Inst. C.E., assisted by C. W. J. Spicer. London: Crosby Lockwood and Son. 1925. Price 42s. net.

The sub-title of this book of some 200 pages, 22 plates, and over 200 figures, is "The Practical Design of Modern Reinforced Concrete Bridges, including notes on Temperature and Shrinkage Effects," and in his preface the author states that his purpose is to amplify the information contained in existing works and, without attempting to deal exhaustively with the subject, to set forth "all that is essential to guide an engineer in the adoption and the design of a bridge to suit any case ordinarily met with." It is difficult to understand what is meant by the words "adoption" and "any case," for Mr. Scott does not deal with location nor with such matters as flood discharges, waterway, permissible road and water levels, and comparisons of types in representative cases of the river crossing problem. The scope of the book is, happily, not extended to include the discussion of such matters, and the space available is, therefore, enough for a very useful presentment of the subject, confined to the actual designing of different types and forms of reinforced concrete bridges and the strictly relevant data and theory. The author's allotment of the space to different parts of the subject is made with sound judgment. The first quarter of the work is devoted to loading, wind pressure, temperature and shrinkage effects, and influence lines, adequately but simply presented. The author then deals in three chapters with arch girder and bow-string girder bridges, nearly one half of these 104 pages being given to arch bridges, a very fair division. A short chapter on hinges is followed by a chapter of 14 pages on foundations and abutments, a somewhat scanty allowance. There is a chapter describing ten representative bridges, and the volume ends with an appendix giving the notation, and a general or preliminary specification for a reinforced concrete bridge of any form.

While he points out that in some cases investigations should be based on first principles, the author's method is to apply graphical means of computing the dimensions of the main supporting members, without investigation of the mathematical proofs, which are to be found in other works. Another, and a reasonable economy of space is the assumption that the reader understands "the design of ordinary reinforced concrete construction"; but calculations such as those of the bending moments of slabs under wheel loads are included, with others specially pertaining to bridge design. The application of theory to the design of arch bridges is lucid, and as far as it goes is satisfactory; but Mr. Scott does not, by means of a general sense of the main elements of the matter, present comparisons of the economics of different types, having regard to quantities of material and the relative costs of different methods of building. Similarly, in the case of girder bridges, he deals adequately with spans but not with whole bridges. He does not, for instance, discuss a typical problem involving alternatives; many or few spans, deep or shallow foundations, and so forth. This criticism applies also to his treatment of foundations and abutments.

One has the impression that the author, who is chief engineer to Considère Constructions, Ltd., has been accustomed to deal with bridge design problems in which the main elements were already decided, rather than to design bridges in the full sense of the term. His book will, however, be useful in helping an engineer in the preliminary stages, because it provides a means of estimating the costs of different forms of reinforced concrete bridges, and it is a really useful and practical work on the actual designing of any of the more usual forms of such bridges. It is a very sane work; and it is perhaps hardly fair to the author to have allowed his use of the word "adoption" to have called forth criticisms which do not in any sense apply to the valuable and well arranged matter with which, to the exclusion of all trivialities, the book is filled.

SHORT NOTICES.

Public Water Supplies, Requirements, Resources and Construction of Works. By F. E. Turneaure, Dr. Eng., and H. L. Russell, Ph.D., with a chapter on "Pumping Machinery," by D. W. Mead, and three chapters on "Quality of Water Supplies," by C. M. Baker. London: Chapman and Hall, Ltd. 1924. Price 30s. net.—This is the third edition of an excellent book. The first edition was published in 1901 and the second in 1908. The present edition does not differ as fundamentally from the second as the second did from the first, but the improvements in various departments which have been made during the past sixteen years or so have been noted, special attention being given to such subjects as consumption of water, stream flow, filtration, chlorination, the quality of water supplies, reinforced concrete in waterworks construction, and pumping machinery. The book is written almost entirely from the American standpoint and deals with very little outside the North American Continent. Nevertheless, though it treats of many things not met with, say, in England, it contains much that is of interest to the water engineer, no matter in what country his work may lie.

The Construction of Wells and Bore-holes for Water Supply and the Elements of the Analysis and Purification of Water. By J. E. Dumbleton, Assoc. M. Inst. C.E. London: Crosby Lockwood and Son. 1925. Price 10s. 6d. net.—It was originally intended that this book should form a revised edition of "The Rudimentary Treatise on Wells and Well Sinking," of J. G. Swindell and G. R. Burnell, but as that was found impossible, owing to the advances which have taken place during the forty odd years since the original revised edition of that book was published, it was decided to make an entirely separate work of it. Nevertheless, certain portions of the original book have been embodied in the present production. After some historical and descriptive notes in Chapter I., the author goes on in successive chapters to deal with the theory of springs, the yield of wells, the construction of wells, and boring, and then discusses, in turn, bore-hole pumps, including air lifts and band elevators, and various notable wells. The last two chapters are devoted to the properties of water, and water analysis and purification. The book is interestingly written and the illustrations are good.

The Management of Marine Engines and Boilers. By E. Prince. London: Scott, Greenwood and Son. 1925. 10s. 6d. net.—This is an eminently practical work giving hints on the maintenance of reciprocating marine engines and return-tube boilers, together with their auxilaries. The descriptive matter is helped out by a number of simple line sketches. Valve setting is explained with the aid of the Zeuner diagram and several faulty indicator cards. The make-up of lubricants is described, there is a chapter on Materials used in Marine Engineering, and the equipment required in a ship's workshop is set out. Taken on the whole, the advice given is quite sound, although some engineers may not agree with all of it—such, for instance, as the feeding of new boilers with salt water to form a protecting skin. A considerable amount of space towards the end of the book is given to the running of engines and boiler tests.

Tables for Reinforced Concrete Floors and Roofs. By R. T. Morgan. London: Chapman Hall, Ltd. 1925. 10s. 6d. net.—The principal part of this book comprises a series of tables giving alternative particulars of reinforcement for slabs ranging from 5ft. up to 16ft. span, and for various loadings between 40 lb. and 448 lb. per square foot based on the assumption that the tension in the metal is 16,000 lb. per square inch and the compression in the concrete 600 lb. per square inch. As Mr. Etchells, past president of the Institution of Structural Engineers, says in a Foreword, it should be as easy, with these tables, to determine the proportions of a floor as to plan out a railway journey with a time table. The author has a peculiar little conceit in using the expression pd for pounds weight, but all the other symbols are readily recognisable.

Pattermaking. By J. G. Horner. London: Crosby Lockwood and Son. 1925. 18s. net.—This is the fifth edition of Mr. Horner's well-known work, and consequently needs little introduction. It has, however, been considerably enlarged, and now includes some 430 pages, while there are over 600 illustrations. The sequence of the chapters has been changed, and some new matter has been added to cover the patternwork required for gear wheels and for machine moulding. The book should prove even more useful than its previous editions to both young patternmakers and journeymen.

The Metalworker's Practical Calculator. By J. Matheson. London: Sir Isaac Pitman and Sons. 1924. 2s.—This is a little book explaining the simple forms of calculation required principally in the smithy for determining the amount of metal which will be required to make any definite object. Allowance is not, however, made for any loss of material during manufacture, such as machining or scaling. The first score of pages is devoted to elementary arithmetic.

Water Power Resources of Canada.

THE Dominion Water Power and Reclamation Service of the Department of the Interior of Canada has recently completed an anlyasis of the water-power resources of Canada—developed and undeveloped—as at February 25th last. From its report it appears that with the installation during the year 1924 of new wheels, aggregating over 300,000 horse-power, there is now installed for all purposes a total of 3,569,275 horse-power, and by the completion of plants at present under construction that figure will be increased by over 600,000 horse-power before the end of this year. Outstanding features of the developments under way or recently completed are their magnitude, the fact that they are not confined to any particular section of the country, but extend from coast to coast, and the large proportion of the power being installed which will be available for public use through the medium of central electric station organisations.

BASIS OF COMPUTATION.

The figures for available water power, which are given in Table I., are based upon rapids, falls and power sites

TABLE I.—*Available and Developed Water Power in Canada.*
February 1st, 1925.

Province.	Available 24-hour power at 80 per cent. efficiency.		Turbine installation, H.P.
	At ordinary min. flow, H.P.	At ordinary six-months flow, H.P.	
1	2	3	4
British Columbia	1,931,142	5,103,460	355,772
Alberta	475,281	1,137,505	34,107
Saskatchewan	513,481	1,087,756	35
Manitoba	3,270,491	5,769,444	162,025
Ontario	4,950,300	6,808,190	1,585,182
Quebec	6,915,244	11,640,052	1,308,106
New Brunswick	50,406	120,807	44,656
Nova Scotia	20,751	128,264	63,957
Prince Edward Island	3,000	5,270	2,276
Yukon and North-West Territories	125,220	275,250	13,209
Canada	18,255,316	32,075,998	3,569,275

or which the actual existent drop or the head possible of concentration, is definitely established or at least well authenticated. Many rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded, and which will only become available for tabulation as more detailed survey work is undertaken and completed. This is particularly true in the relatively unexplored northern districts. Nor is any consideration given to the power concentrations which are feasible on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting only at such points as definite studies have been carried out and the results made matters of record. It is explained, in fact, that the figures given are based on definite rapids, falls and power sites, and may be said to represent the minimum water power possibilities of the Dominion.

The power estimates have been calculated on the basis of twenty-four-hour power at 80 per cent. efficiency for conditions of "ordinary minimum flow" and "ordinary six months' flow." The "ordinary minimum flow" is based on the averages of the flows for the two lowest periods of seven consecutive days in each year, over the period for which records are available. The "ordinary six months' flow" is based upon the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the maximum for that year. The average of such maximum figures for all years in the period for which data are available is the estimated maximum used in the calculation.

AVAILABLE AND DEVELOPED TOTALS.

The known available water power in Canada, from all sources and within the limitations outlined, is 18,255,000 horse-power for conditions of ordinary minimum flow, and 32,076,000 horse-power under a flow estimated for maximum development, *i.e.*, to be depended upon for at least six months of the year. It is believed that these are conservative estimates, since an analysis of the water power plants scattered from coast to coast, concerning which complete data are available as to turbine installation and satisfactory information as to stream flow, gives an average machine installation 30 per cent. greater than the six-month flow maximum power. Applying this, the figures quoted above, therefore, indicate that the present recorded water power resources of the Dominion will permit of a turbine installation of 41,700,000 horse-power. The total installation to date in water wheels and turbines through the Dominion is 3,569,275 horse-power. In other words, the present turbine installation represents only 8½ per cent. of the recorded water power resources.

CURRENT PROGRESS.

Reference to the more outstanding developments at present under construction may be of interest at this point. The development of British Columbia's water power resources proceeded apace during 1924, and while none of the undertakings reached completion, much important work preliminary to a greatly increased installation for 1925 was carried on. The British Columbia Electric Railway Company raised the level of the Stave Lake dams, commenced the installation of a fifth unit of 15,000 horse-power, and is re-winding the existing units to give a total rated capacity of approximately 85,000 horse-power in its power station. The same company also commenced work on the diversion of the waters of Alouette Lake to a power-house on Stave Lake to have a capacity of 12,500 horse-power. The West Kootenay Power and Light Company entirely demolished its 4016 horse-power plant at Lower Bonnington Falls on the Kootenay River, and commenced the construction of a new plant of an ultimate capacity of 60,000 horse-power, of which 40,000 horse-power will be installed during 1925. In Alberta, the Dominion Parks Branch of the Department of the Interior placed in operation a hydro-electric development of 960 horse-power for lighting and general power purposes in Banff. The city of Winnipeg provided for the installation of three additional units of 7300 horse-power, each in its Winnipeg River station, and completed a steam stand-by plant of 11,000-kilowatt capacity as protection against interruptions in its hydro-electric supply. The stand-by plant's boilers, in conjunction with two 7500 kVA. electric steam generators using surplus or off peak hydro-power, will provide steam for a central heating system for a considerable portion of the business section of the city.

Ontario and Quebec both added greatly to their installation during the year. The Ontario Hydro-electric Power Commission doubled the capacity of the Nipigon station, bringing the total to 50,000 horse-power, brought two more 55,000 horse-power units, Nos. 6 and 7, into operation at the Queenston station, increased the capacity of the Eugenia Falls development by 2000 horse-power, brought new stations of 1200 horse-power capacity at Bingham Chute near North Bay and 6600 horse-power at Dam 8 on the Trent River into operation, and did preliminary work, which will result in considerably further installation during 1925. The Canadian Niagara Power Company installed a new unit of 12,500 horse-power, bringing the total installation of its station to 121,500 horse-power. In Northern Ontario the Hollinger Consolidated Gold Mines, Ltd., completed a 24,000 horse-power development on the Abitibi River at Island Falls, the Northern Ontario Light and Power Company increased the capacity of its Matabitchouan station to 13,200 horse-power, the South Bay Power Company increased the capacity of its plant, and the Lorne Power Company added a 2750 horse-power unit to its Nairn Falls station on the Spanish River. In the extreme westerly part of the province at Kenora the Backus-Brooks Company enlarged its Winnipeg River plant to 12,000 horse-power.

In Quebec the St. Maurice Power Company installed 120,000 horse-power at La Gabelle on the Ste. Maurice River, and the Quinze Power Company 20,000 horse-power at Ke Kek Falls on the Quinze River, the power from the latter plant being transmitted to the Porcupine gold-fields in Ontario. The Montreal Light, Heat and Power Consolidated added two units of 11,300 horse-power each to its Cedars station on the St. Lawrence River, bringing the plant to its total designed capacity of 200,000 horse-power. Other installations in the province were those of the St. Regis Paper Company, near Godbout, 600 horse-power; the town of Buckingham, 600 horse-power; the town of Bagotville, 1350 horse-power; the town of Jonquiere, 1800 horse-power, and an addition of 7500 horse-power to the plant of the Ottawa and Hull Power Company at Hull. In both Ontario and Quebec rapid progress was made on developments which will be completed before the end of 1925.

In the Maritime Provinces considerable activity also prevailed. The Nova Scotia Power Commission completed a 5500 horse-power development at Malay Falls, East River Sheet Harbour, and a 6290 horse-power development at Ruth Falls on the same river, and also added a 150 horse-power to its Mushamush plant. In addition, new installations or betterments to existing stations provided extended service to a number of municipalities. In New Brunswick, while no construction was undertaken, intensive studies were carried on at Grand Falls on the St. John River, with a view to development in the near future.

UTILISATION OF DEVELOPED WATER POWER.

The 3,569,275 horse-power at present installed throughout the Dominion is apportioned to the following uses—see Table II.

(1) 2,696,997 horse-power in central electric stations for general distribution for domestic, municipal and commercial lighting and power purposes.

(2) 503,039 horse-power installed in pulp and paper mills; in addition, there is used in pulp and paper mills 228,755 horse-power purchased from central electric stations.

(3) 369,239 horse-power installed in industries other than central electric stations and pulp and paper mills.

The total installation for the Dominion averages 386 horse-power per 1000 population, a figure which places Canada among the leading countries of the world in *per capita* utilisation of water power.

Throughout the Dominion at the present time there are 291 hydro-electric central stations, with a total turbine installation of 2,696,997 horse-power and a generator installation of 2,046,104 kVA. Of these totals, 208 stations of a total capacity of 1,832,736 horse-power, are owned by commercial organisations and 83 of a total capacity of 864,261 horse-power by municipal or other public organisations. The turbines vary in size from the 10 horse-power wheel used for hamlet lighting, to the great 55,000 horse-power units of the Chippawa-Queenston station, and each year sees an increase in the average horse-power per turbine unit, and also in the average horse-power installed per station.

WATER POWER IN THE PULP AND PAPER INDUSTRY.

Perhaps the most conspicuous feature of recent industrial progress in Canada has been the growth of the pulp and paper industry, due to the fortunate occurrence of tremendous supplies of growing pulp wood in close proximity to readily developable water powers of a size to provide the large amounts of power essential to the conversion of the raw material into the finished product. The importance of ample supplies of low-priced power lies in the fact that it takes practically 100 horse-power to produce a ton of daily output of newsprint. A recent development of interest affecting the power consumption of this industry is the rapid adoption of electric steam boilers as a means of transforming any surplus of available electric energy into steam for pulp cooking, dry, heating, &c.

There are 122 pulp and paper mills operating in Canada by hydraulic or hydro-electric power, utilising a total of 731,794 horse-power. This is made up of 503,039 horse-power installed by the mills themselves and 228,755 horse-power purchased from hydro-electric central stations. The rapid development of the electric drive in this industry is indicated by the fact that 215,472 horse-power of the installation in the mills is connected to generators, which, added to the 228,755 horse-power purchased power, gives a total electric drive of 444,227 horse-power, or over 60 per cent. of the power used.

CAPITAL INVESTED IN WATER POWER.

The investment represented by Canada's present hydraulic installation of 3,569,275 horse-power has been recently made the subject of an intensive study based largely on the figures of the annual census of hydro-electric central stations. Due allowance being made for all the varying factors entering into the development and use of hydraulic power, the statement that a conservative estimate of the capital investment in Canadian water power developments amounts to 767,000,000 dollars, is, it is maintained, warranted.

In Table II., Col. 2 includes only hydro-electric stations which develop power for sale, while Col. 3 includes only water power actually developed by pulp and paper companies. In addition to this total, pulp and paper companies purchase from the hydro power central stations given in Col. 2, 96,985 horse-power in Ontario, 131,120 horse-power in Quebec, and 650 horse-power in New Brunswick. The total hydro power utilised in the pulp and paper industry is therefore 731,794 horse-power. Col. 4 includes only water power actually developed in connection with industries other than the central station and pulp and paper industries. These industries also purchase power in bulk from the central stations given in Col. 2. Col. 5 includes all turbines and water wheels installed in Canada. Col. 6 shows the population at June 1st, 1924, as estimated by the Dominion Bureau of Statistics; while Col. 7 averages the developed water power per 1000 population. If population be taken at the estimated figure for February 1st, 1925, the total installation per 1000 population in Canada becomes 383.

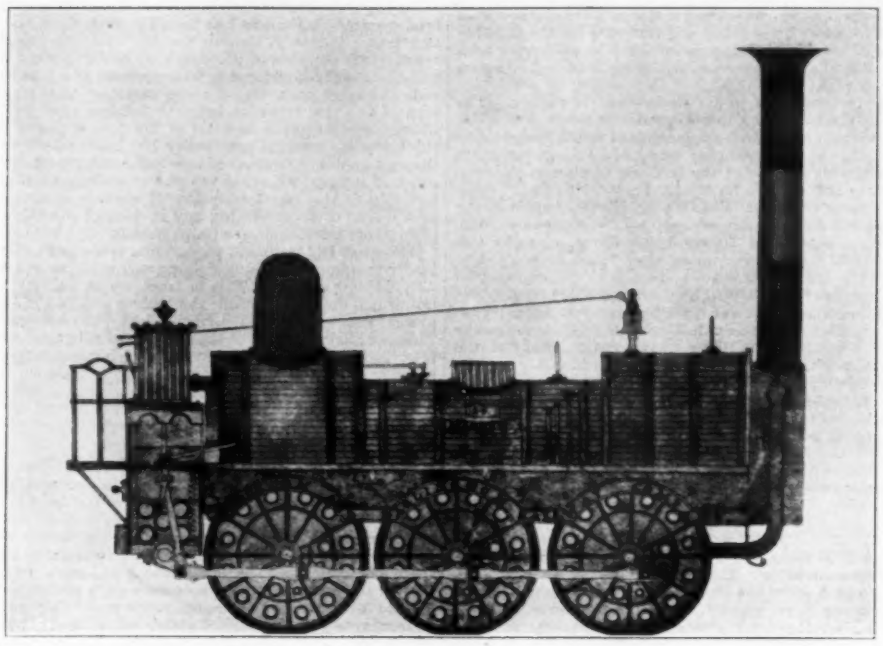
TABLE II.—*Developed Water Power in Canada.*
February 1st, 1925.

Province.	Turbine installation in H.P.				Population, June 1st, 1924.	Total installation per 1000 population.
	In central stations.	In pulp and paper mills.	In other industries.	Total.		
1	2	3	4	5	6	7
British Columbia	242,401	55,140	58,181	355,722	553,000	643
Alberta	33,340	—	767	34,107	637,000	54
Saskatchewan	—	—	35	35	815,000	.04
Manitoba	145,625	—	16,400	162,025	647,000	250
Ontario	1,246,203	178,989	159,990	1,585,182	3,062,000	518
Quebec	965,110	237,851	105,145	1,308,106	2,480,000	527
New Brunswick	23,613	13,728	7,315	44,656	399,400	112
Nova Scotia	30,417	17,331	16,209	63,957	533,000	120
Prince Edward Island	288	—	1,988	2,276	87,700	26
Yukon and North-West Territory	10,000	—	3,209	13,209	12,040	1,100
Canada	2,696,997	503,039	369,239	3,569,275	9,226,140	386

AT Lostock Junction, on the Lancashire and Yorkshire section of the London, Midland and Scottish Railway, the lines from Preston and Wigan join and run thence to Bolton. In consequence of a complaint from enginemen the junction was inspected by the chief permanent way inspector, who reported to the district engineer that "the junction was in need of extensive repairs, being in bad alignment. It also required lifting; the fastenings and several of the crossing timbers required renewal." The inspector considered that the V crossing should be set back about 6ft., and intended that a survey should be made. The permanent way inspector for that section was told what was proposed, but not instructed to do it. He, however, told his sub-inspector to carry it out, and that was done on Sunday, January 4th. The work, it will be appreciated, was a serious undertaking, but the sub-inspector was satisfied with having the distant signals kept in the "on" position, and did not send out flagmen. What was worse: the depth of the wing and of the V rails was not uniform, the former being ¾in. deeper than the latter. Moreover, whilst the chairs were double-spiked the trenails were not driven, and the distance blocks were not fixed in the crossing. As a consequence an express train was derailed, and the report by Sir John Pringle, that was the sequel to the accident, concludes as follows:—"I wish to observe that improvement in the lay-out of a curve and junction of this description cannot properly be determined without an accurate survey and re-alignment, and understand that instructions have been given which will prevent the procedure adopted in this case . . . from being carried out in future."

THE LOCOMOTIVE MAGNET AS RECONSTRUCTED

TIMOTHY HACKWORTH, SHILDON AND SOHO, ENGINEER



An Old Stockton and Darlington Railway Locomotive.

The Magnet, No. 24, of the Stockton and Darlington Railway was a locomotive with long and creditable service. Designed and built by Timothy Hackworth at Shildon in 1835, it was for the first few months chiefly employed as a coaching engine, and afterwards in the principal trade of the company, that of "leading" coals. In general appearance it closely approximated to the type of the six engines known as the "Wilberforce" class and built between 1831 and 1833. These engines had upright cylinders mounted behind the boiler, with direct action to a shaft with cranked ends in fixed bearings, and were carried on six wheels all coupled. Ample heating surface was provided, and the engines proved very successful for heavy loads at the slow speed then demanded. The Magnet had cylinders of 15in. diameter and a stroke of 16in. There were no less than 110 copper boiler tubes, 1¾in. diameter, fitted round a tapered fire tube, the whole being termed a return multitubular fire tube. The cost of the locomotive with two improved tenders was a thousand guineas. It began work in July, 1835, and its satisfactory performance resulted in a second engine being built from the same plans in 1836, this being the Enterprise, and the builders William and Alfred Kitching, of Darlington.

The vignette at the head of the Stockton and Darlington Railway time-table for 1837 shows the original appearance of the Magnet, which continued in regular service for many years. It took part in the opening of the Great North of England Railway for mineral traffic in 1841, and on that occasion, in company with the Tory, conveyed a long coal train from Darlington to York.

In 1850, having completed fifteen years of honest work, a thorough overhaul, which in effect amounted to reconstruction, became necessary. The work was undertaken by Hackworth, the original designer, at his Soho works, Shildon, and some interest attaches to the fact, since it was actually the last locomotive work with which he was associated, as he died in June of that year and before the alterations were completed.

It says something for the general efficiency of the type of locomotive of which the Magnet was an example, that so late as the year 1850 many of the outstanding features introduced twenty years before were still considered worthy of retention. Foremost among them were the old upright inverted cylinders, with the rods working to a jack shaft, through which power was carried to six coupled wheels known for a generation as "plug" wheels. The long-continued survival of such a type, in common use in the North of England, was undoubtedly due to its economical working. Speed for coal trains was still quite a secondary matter. The engines were slow, cheap and reliable, each quality reckoned a virtue and valued accordingly.

The photograph here reproduced, and as far as we are aware not previously published, shows the Magnet in its reconstructed form. The curious shape of the boiler shows that it had been lengthened by additions of larger diameter, while it would seem that part of the original boiler was retained. The old "Wilberforce" type had a space of 6ft. between boiler and cylinders, which was obviously reduced in the engine as reconstructed. The original of our illustration is in the possession of a descendant of John Montrey, who, having driven the engine Victory in 1829, became the first driver of the Magnet, and appears to have remained in charge of it through a great portion of its career.

Faraday House Old Students' Association.—Old students are reminded that the annual smoking concert will be held at the Hotel Cecil (Prince's Hall) on Friday, May 1st, at 8 p.m., with the president, Mr. H. W. H. Richards, M.I.E.E., in the chair. Further particulars may be obtained from the hon. secretary, Faraday House, Southampton-row, W.C. 1.

Constant Current Motors.

In our issue of November 21st, 1924, we published an abstract of a paper on a new system of driving ship and other auxiliaries, read by Mr. Gilbert Austin before the Institution of Engineers and Shipbuilders in Scotland. We are indebted to Mr. James C. Macfarlane of the Macfarlane Engineering Company, Cathcart, Glasgow, for the following notes on the speed and torque characteristics of the Austin motor.

It will be remembered that the author of the paper has adopted a series direct-current system for driving auxiliaries. Generators and motors of standard pattern are utilised, the special characteristics required in the case of the generator, for providing a current of substantially constant value for rapidly varying loads, being obtained by means of a specially designed exciter. The torque chacteristics of the motor are obtained by means of a small regulating motor, the armature of which is inserted in the main motor field circuit, so that the back electromotive force produced opposes the electromotive force of the source of supply to the main motor field windings.

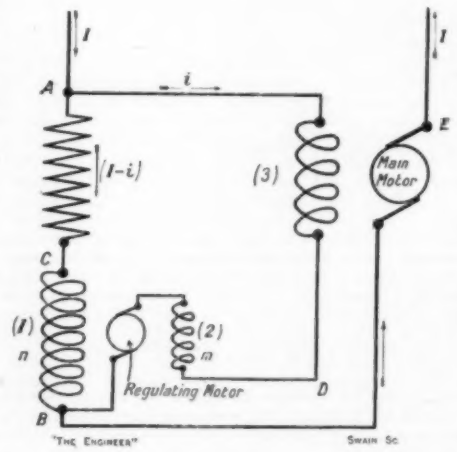


FIG. 1

The object of these notes is to show that practically any shape of speed and torque curve can be produced by suitably proportioning the field winding of the regulating motor.

Referring to Fig. 1, the constant current I reaches the motor at terminal A and leaves it at terminal E, but before reaching E it divides into two parts $(I - i)$, and i uniting again at terminal B. The regulating motor is supplied with two field windings 1 and 2 respectively, having n and m turns per pole respectively, and m may or may not oppose n as desired.

The current $(I - i)$ flowing in circuit A C B, the total resistance of which is R, creates a potential difference $(I - i)$ R between the terminals A and B, and this causes the current i to flow in the circuit A D B. This circuit contains the main motor field winding 3, and the resistance of the whole circuit is R_1. When the motor armature is moving at any speed, which we will call "small s," the back E.M.F. of the regulating motor opposes the potential difference between the terminals A B, and at light load may be taken for the purposes of this investigation as equal to this difference, thereby making i for this condition zero.

At speeds above the light load value (large S), i becomes negative, and the motor now acts as a generator.

Assuming the permeability of the magnetic circuits of both main and regulating motors constant, the fluxes in both machines will be proportional to their field M.M.Fs. and in the main motor, as the armature current is constant, the above assumption means that the torque of the machine is proportional to its field current.

A simple relationship between the speed and the field current can readily be established, and if the magnetisation curve for the motor is available, torque and speed curves of reasonable accuracy throughout can be plotted.

The back E.M.F. of the regulating motor is—

$$k\,[n\,(I - i) + m\,i]\,s \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where k is a constant presently to be determined, and if m opposes n it is to be considered negative.

At light load—

$$s = S,$$

and, as already stated, the potential drop across the circuit A C B is balanced by the back E.M.F. of the regulating motor, making i zero.

Substituting these values in (1), and equating—

$$k\,n\,I\,S = I\,R$$

$$k = \frac{R}{n\,S}$$

At any speed s the main motor field current i is produced

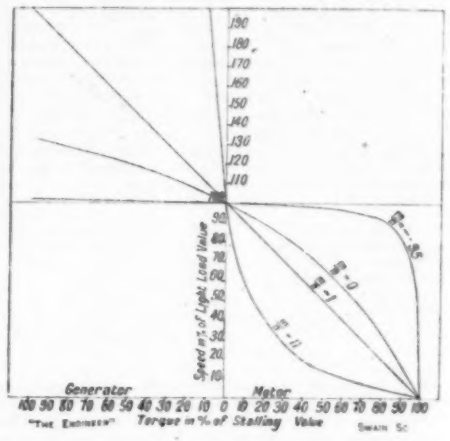


FIG. 2

by the difference between the terminal potential difference of A B and the back E.M.F. of the regulating motor, thus—

$$(I - i)\,R - \frac{R}{S}\left((I - i) + \frac{m}{n}\,i\right)s = i\,R_1$$

which reduces to—

$$s = \left[\frac{I - i\left(\text{Unity} + \frac{R_1}{R}\right)}{I - i\left(\text{Unity} - \frac{m}{n}\right)}\right] S \quad . \quad (2)$$

An examination of the above shows—

(a) That the nearer $\frac{m}{n}$ approaches $\frac{R_1}{R}$ in value, m being negative, the more nearly does the speed become constant with varying load.

(b) If $\frac{m}{n}$ is equal to unity, m being positive, the speed and torque curve becomes a straight line.

(c) If $\frac{m}{n}$ is large (m positive), the speed and torque curves are very similar to that of the series-wound motor on the constant potential system with the difference that the Austin motor can be stalled indefinitely.

Altering the ratio $\frac{R_1}{R}$ also alters the shape of the curves, but the most economical value for $\frac{R_1}{R}$ from the point of view of power waste is unity. In other words, R should equal R_1, and both should be as small as possible for maximum efficiency.

Fig. 2 gives the characteristic curves for four different values of $\frac{m}{n}$, viz.:—

$\frac{m}{n} = -.95$, zero, unity, and 11 and for $\frac{R_1}{R}$ = unity.

From the foregoing it may be observed that a motor of suitable characteristics is available for any industrial drive, and the small amount of switchgear necessary and the simplicity of the wiring makes the system an attractive one for many purposes.

Government Tests of Agricultural Machinery.

The report of the Committee appointed by Sir N. Buxton, Minister of Agriculture and Fisheries under the late Government, to formulate a detailed scheme for individual tests of agricultural appliances, has recently been issued. The Committee comprises Professor W. E. Dalby, F.R.S., chairman; Mr. Thompson Close, of the Ministry of Agriculture and Fisheries; Mr. F. S. Courteney, M. Inst. C.E., Consulting Engineer to the Royal Agricultural Society of England; Mr. Henry Dack; Mr. Harry German; Mr. W. Harrison; Mr. B. J. Owen, M.Sc., M.Eng., Director of the Institute for Agricultural Engi-

COMBINED ROAD SWEEPER, SPRINKLER AND DUST COLLECTOR

KARRIER MOTORS, LIMITED, HUDDERSFIELD, ENGINEERS

neering, Oxford; and Dr. T. E. Stanton, C.B.E., F.R.S., of the National Physical Laboratory. The secretary is Mr. P. Barker, of the Ministry of Agriculture and Fisheries. The object of the scheme is to test individual machines that are on the market and to issue official certificates and reports which will give farmers and the public accurate and independent information regarding the utility, efficiency, reliability, working cost, maintenance, &c. Machinery of either home or overseas manufacture will be tested, and the cost will be borne by the applicant for the test in accordance with a schedule of fees. The general regulations which have been issued state that when a machine or implement is produced in quantity, the example submitted for test must be of standard design and quality, and the Ministry reserves the right to select a machine from the manufacturer's stock, while if the Ministry originates a test the manufacturer shall be notified, and shall be furnished with copies of the certificate and report.

After considering various alternatives, the Committee has come to the conclusion that the best method of charging fees is according to the types and characters of the machines to be tested, and a scale has been drawn up, subject to revision. It is thought that whilst the testing institution should be reimbursed by the Ministry for such expenses as fuel, horses, unskilled labour and any expenses directly disbursed in connection with a test, no charge, or at any rate only a nominal one, should be made for the use of scientific apparatus or for technical assistance in supervising the test and preparing the certificate and report. The Committee considers that the carrying out of the tests should enable the institutions concerned to glean some valuable information bearing upon their work, and it is considered that such State-aided institutions should be willing to assist with tests without being reimbursed for the total cost.

The conditions prevailing in agriculture are so varying as to preclude as a general rule the possibility of tests being conducted under identical conditions. Consequently, a test must be regarded as complete in itself, and should be judged in the light of the conditions under which it was conducted. Each test will, however, proceed on the same general lines, and data will be collected under the following heads so far as they may be applicable to a particular case:—

(1) *Mechanical.*—The mechanical efficiency of a machine or implement and its components will be tested: (*a*) in the laboratory, where the design, material, friction losses, &c., will be determined; and (*b*) in the field—*i.e.*, under working conditions—where the draw bar load, adhesion, degree of soil disruption and load exercised by disruption in the case of tillage implements, &c., will be determined.

(2) *Physical.*—The physical factors involved when the machine or implement performs its function would be shown under this head, *e.g.*, in the case of tillage implements, the following observations would be recorded: (*a*) Soil density before and after; (*b*) soil moisture before and after; (*c*) plastic deformation and degree of disturbance.

(3) *Economic.*—The actual costs of performing the operation would be recorded and information tabulated as follows: (*a*) Capital cost; (*b*) cost of maintenance, including repairs and replacements, if any; and (*c*) cost per unit of work done.

It is proposed to take advantage of the facilities existing at agricultural research stations and other institutions receiving financial aid from the State. At first, it will probably be found advisable to restrict the tests to a small number of selected institutions, although special cases may arise from time to time which will render desirable the co-operation of an institution specialising in a particular subject, and not participating in general tests. The selection of any institution for a test would as a rule entail the employment of a duly qualified person on the staff of that institution to assist with the testing work.

New Type of Road Sweeper, Sprinkler and Collector.

A new type of vehicle, which is a road sweeper, sprinkler and dust collector combined, has recently been put on the market by Karrier Motors, Limited, of Huddersfield. It is illustrated in the accompanying engravings. The vehicle has an ordinary commercial vehicle chassis, to which is added a sweeping attachment. Below the radiator, in front of the machine, is the sprinkler comprising a transverse tube, fitted with numerous nipples and fed from a small semi-rotary pump situated under the chassis on the near side of the machine. The pump is controlled from the driver's seat, so that the water can be turned on or off at will.

Immediately behind the front wheels, and set at a suitable angle, is the main brush, which is made in sectional form for easy handling and renewal. The sections are mounted on a square shaft, which is driven by a chain and worm gear from the gear box. The raising or lowering of the brush is performed by means of a lever on the driver's left, and the brush pressure is controlled by a hand wheel, which is seen in the illustration of the offside of the machine. Parallel with the brush is an elevator system, which comprises three geared rotors, one above the other in a casing. These rotors are revolved at a high speed in opposite directions and are constructed of brush-like vanes, four in number, which are capable of easy and speedy adjustment when necessary. They are driven by a chain running from a sprocket on the bottom rotor to another on the top rotor, passing on its way under the sprocket of the middle rotor, so that the top and bottom rotors revolve in the opposite direction to that of the middle one. The brush, which projects beyond the width of the machine, cleans out the gutters and the sweepings gradually work their way, by virtue of the angle of the brush, to a point opposite the rotor casing. At that point, the rotation of the main brush throws the sweepings on to a pan at the bottom of the rotor case, which, in turn, throws the dirt forward on to the bottom rotor brush, which passes it on to the middle rotor, while the top rotor receives them from the middle rotor, and throws them into the body of the machine. The makers claim that the sweepers will leave a clean-swept street in its wake, no matter how dirty the street may be; that it will lift any of the ordinary litter with which the streets become covered; and that it can sweep 30 miles of streets in the course of an eight-hour day.

When the load has been collected, the average load being 2 tons, the driver turns off the sprinkler, lifts the main brush, stops the rotors and drives the vehicle off to the dump. On arrival alongside the dumping point, a small spring catch, which holds the body and is operated by a lever, is released by the driver. A firm push is then given to the body, which moves sideways until it reaches a point over the centre of gravity, when it automatically tips over and deposits its load. The body is returned to its position ready for sweeping operations again by a lift up and a push. The release lever referred to is not visible, but it just under the body, near the brush adjustment handle.

The water tank is placed behind the body, and at the extreme rear there is a capacious tool box. The engine of the machine is designed to develop 25 horse-power. The steering wheel is placed on the near side to enable the driver to watch the gutter, but apart from that and from a special form of gear-box fitting, the chassis design follows very closely the lines of those of an ordinary wagon chassis.

The makers state that the machine shows a very considerable saving over old methods of street cleansing, and that it can be operated at a cost of about ¼d. per mile run.

Local Reflection of Wireless Waves from the Upper Atmosphere.

In a letter to *Nature*, Messrs. E. V. Appleton and A. F. Barnett, of Cambridge, deal with some recent experiments carried out for the Radio Research Board of the Department of Scientific Research. Measurements have been made of the diurnal variations of the signals received at Cambridge from the stations of the British Broadcasting Company. During the daytime these signals have been found to be fairly constant, but night time variations of intensity have been measured at distances from the transmitter as short as 50 miles. For example, the signals from London at Cambridge are found to be constant during the day, but at about sunset variations, which are often of a periodic character, begin and continue through the dark hours. In this case the mean night value is very little different from the day value. For more distant stations—for example, Bournemouth—the phenomena are different. During the day the signal is weak and constant; but after sunset the intensity increases and, though variable, the signal maxima may be several times the day value. In this case the variations in signal intensity are larger, less rapid, and less markedly periodic than in the case of the London signals.

These effects may be explained in a general way if an atmospheric reflecting layer is postulated which is comparatively ineffective for the waves of this frequency during the daytime but bends them down very markedly at night. According to this view two rays arrive at the receiver at night, one nearly along the ground, which may be called the direct ray, and the other returned from the atmosphere, and called the indirect ray. In the case of the London signals the direct ray is considered as being strong and constant compared with the indirect ray; and the night time variation is considered as being due to interference between the direct and the weak indirect ray. For the longer distance transmission, the stronger night time signal is to be attributed to the indirect ray.

If the reflecting stratum is imagined to be at a height greater than, say, 50 kiloms., the above interpretation indicates bending back at relatively small angles of incidence—for example, if London is considered, and the height is assumed to be 100 kiloms., this angle of incidence is about 22 deg. Such high grazing angle reflection from the Heaviside layer has not usually been considered possible, and the investigators have therefore attempted to examine the phenomena in a more direct manner. The method adopted has been to vary the frequency of the transmitter *continuously* through a small range and attempt to detect the interference phenomena so produced between the two rays. From the measurements made it was estimated that at a distance of about 100 kiloms. from the transmitter, the effects of the direct ray and the indirect ray at night would be approximately equal.

The British Broadcasting Company, on being approached, very kindly consented to collaborate in the experiments and to use the Bournemouth station as the transmitter. Oxford, being about 140 kiloms. from Bournemouth, was chosen as the receiving site, and excellent facilities for the installation of the receiving station were provided for us Oxford Electrical Laboratory by Professor J. S. Townsend and Mr. E. W. B. Gill. Captain A. G. D. West, of the B.B.C., who was in charge of the Bournemouth end of the experiment, arranged the transmitter so that a known frequency change could be produced uniformly during a given time—for example, 10 to 30 seconds—while the aerial current remained practically constant. The received signal intensity at Oxford was determined with a receiver specially designed to give approximately uniform sensitivity over this band of frequencies. The resulting signal currents were measured by moving coil and small Einthoven galvanometers. Mr. F. G. G. Davey gave valuable assistance at the receiving station. Land-line communication was also maintained between the two stations during the period of the experiments for control purposes.

Two sets of experiments were carried out on December 11th, 1924, and on February 17th, 1925, and in both cases quite different examples of successions of interference bands were observed as the wave-length was changed, the intensity varying from a maximum value almost to zero as was arranged for by choice of distance. If we assume, Messrs. Appleton and Barnett state, the simplest interpretation of these interference phenomena and regard them as analogous to those of a Lloyd's mirror fringe system, the effects may be viewed as follows. For a direct ray path of length a, a higher ray path of length a' and a given wave-length λ, the higher ray arrives N wave-lengths behindhand as compared with the lower ray where $N = (a' - a)/\lambda$. If N is an integer the waves steadily reinforce unless a' is changing, while if N is halfway between two integers they are steadily opposite in phase. If the wave-length is gradually increased to λ' at the sending station, alternations of intensity may be expected, the number being $(a' - a)/\lambda - (a' -)/\lambda'$. The experimental observations according to this simple interpretation indicate a path difference $(a' - a)$ of the order of 80 kiloms., which is consistent with a reflecting layer at a height of about 85 kiloms. Evidence was, however, obtained that the results may be somewhat complicated by the elliptical polarisation of the indirect ray, in which case the above estimate of the height may have to be revised. Further experiments on this point are in progress. But the interference phenomena between two rays depending on the existence of a deflecting layer seem definitely established.

It has been usual to attribute the difference between day and night strengths of wireless signals to a difference in the sharpness of the boundary of the effective atmospheric layer, the lower boundary being assumed sharper by night than by day. The investigators think, however, that the transition cannot be sharp compared with the wave-length, particularly for the short waves used, and therefore the term "reflection" used for convenience above, must be taken as meaning "ionic deflection."

It is imagined, therefore, that at night the layer is sufficiently high and intense to permit of ionic deviation taking place, the ray being turned through large angles without undue absorption. During the day the ionisation due to solar agencies throws the ray down at lower levels—for example, 40–50 kiloms.—and here, although ionic refraction can take place, the collisional "friction" causes heavy

absorption at these short wave-lengths and high grazing angles. The difference in the action of the atmospheric ionisation between day and night is therefore to be taken as due to the differences in height—and therefore density—of the effective layer, and not as due to the difference in the sharpness of the boundary of the layer as has been usually assumed.

These and other experiments suggest the inference that, at distances greater than about 100 miles from a wireless transmitter of these wave-lengths—for example, 300–400 m.—night time reception is dependent almost entirely on the upper indirect ray; and evidence is not lacking that, owing to the more effective reflection by the ionised layer at smaller grazing angles, the signal strength maximum may, in some cases, increase with increase of distance from the transmitter.

A New Pneumatic Drill.

We recently had an opportunity of witnessing some brief tests of a pneumatic drill which appears to possess several advantages over most existing types and certainly should prove useful in service where its maintenance is liable to be neglected. The machine, which is being made by the E. M. Ling Engineering Company, Limited, of 12, Grosvenor-gardens, S.W.1, is illustrated by the engravings below, both dismantled, to show the component parts, and at work during one of the tests. The line drawings give sections through the air motor and the drilling head.

THE DRILL UNDER TEST

The principle of the air motor is that of the familiar rotary engine with sliding vanes; but several improvements in detail have been embodied in the design. The cam path, against which the vanes abut, has, it will be seen, a compound curvature. There are two circular arcs of different radii connected by transition curves, the result being that the vanes have very little radial movement during the time that they are subjected to the side pressure of the air. As a consequence friction is reduced to a minimum, while the slots of the rotor in which the vanes are accommodated are not worn materially.

The cam path itself is of hardened steel ground to shape after it has been hardened and it is pressed into an aluminium alloy casing. The vanes, also, are of hardened steel and are drilled from the back to make them as light as possible. A light spring is used to ensure that the vanes shall abut against the cam at starting.

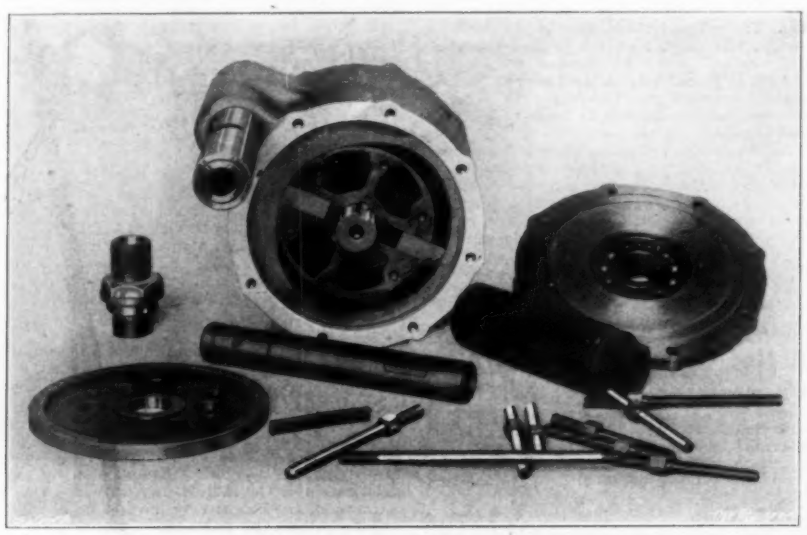
The chief objection which has always been raised against this type of motor is, of course, the wear of the vanes against the cam, as there can only be line contact between the two, and centrifugal force produces considerable pressure on this narrow surface. For this reason we were specially anxious to see the condition of one of these motors after it had been in service, and were rather surprised to find, on opening out one which had been in use for about twelve months, that so little wear had taken place that the grinding scratches were still visible on the cam path and vanes, while the vanes were a good fit in the rotor slots.

Another difficulty connected with this general type of motor, which has been overcome in the machine under review, is the wear of the vanes and rotor against the end covers. A loose shrouding disc is arranged at each end of the rotor between it and the end covers. The discs have a clearance all round of about one thousandth of an inch and are drilled so that the air pressure on both sides is balanced. When the machine is running a thin film of oil fills the clearance spaces and it appears as if there is no metallic contact here between the moving and fixed parts.

This type of motor is, of course, completely reversible by merely interchanging the admission and exhaust ports, and the interchange is effected by a simple rotating sleeve in the admission passage, which can be plainly seen in the sectional drawing.

The rotor spindle of these machines runs at some 1500 revolutions per minute and naturally needs gearing down to the drilling spindle. Several different arrangements of gearing have been devised, and that shown in our illustrations is intended for getting into confined corners. The arrangement is so obvious in the drawing that it needs no description, but it is noteworthy that the gear can be very easily taken apart for inspection and overhaul. It will be noticed that the drilling thrust is taken by a ball washer, while the rotor runs in ball bearings.

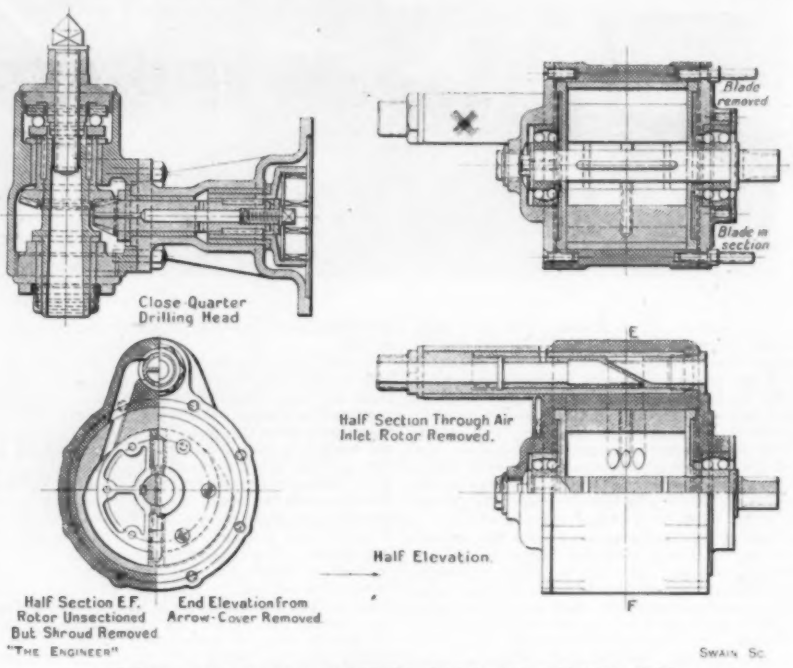
The weight of the machine is about 30 lb., and its nominal capacity is the drilling of a 1¼in. hole in mild steel. The speed of the drilling spindle is 170 revolutions per minute. The distance from the point of the feed screw to the drill socket is 7¾in. and the distance from the centre line to the fouling point of the spindle casing is $1^{7}/_{16}$in. The overall length is 17¼in.



DRILL DISMANTLED SHOWING THE COMPONENT PARTS

During the tests which we witnessed the machine was set up, as shown in the engraving, to drill 1¼in. holes in mild steel, and was supplied with compressed air at a pressure of approximately 100 lb. per square inch. It was obvious that the drill itself was not in first-class order, as one lip was cutting faster than the other, but as there was no convenient drill grinding machine the tests were carried on. The drill was fed into the work until it was cutting a full sized hole, and then the times were taken by means of a stop watch. Throughout the several holes drilled the feed was consistently at the rate of ¼in. for every half minute, but we understand that since our visit the same machine has drilled at the rate of 1¼in. a minute for a 1¼in. diameter hole.

The air consumption of pneumatic tools is generally considered to be a matter of minor importance, as all such machines are admittedly uneconomical, and they are judged rather by their ability to stand up to hard usage and to "get the job done." It may be of interest, nevertheless, to mention that, so far as we could estimate from the output of the compressor supplying the drill, and the slight drop in the pressure in the receiver, the air consumption during the tests was about 60 cubic feet of free air per minute.



SECTIONS OF THE LING PNEUMATIC MOTOR AND DRILLING HEAD

THE PUNJAB HYDRO-ELECTRIC SCHEME.

Some interesting details of the Punjab hydro-electric scheme are given in an article appearing in the *Manchester Guardian* of April 9th. Use will be made of the snow-fed waters of the river Uhl, which is a tributary of the Beas. Water will be diverted through 2½ miles of tunnel, 9ft. in diameter, in solid granite, and will then be dropped through a fall of 1,800ft. to the first power station, where 36,000 kilowatts will be generated. After the construction of a comparatively small dam, however, on the site, it will be possible to increase the power to 70,600 kilowatts, and when the demand for power still further increases, it will be possible to conduct the water through 3 miles of open duct and to drop it through a second and lower fall of 1200ft., thus providing another 48,000 kilowatts. A total output of over 118,000 kilowatts will therefore be provided, which is more than sufficient to meet the needs of the present generation in an area extending from Delhi in the south to Sialkot and Lyallpur in the north. There is also a third fall, which could be developed later if required. The project naturally involves railway communication to the power station, and a secondary benefit of the scheme will be the opening up of the rich and thickly populated Kangra Valley, which is one of the world's beauty spots. For the completion of the scheme from three and a half to four years will be required, so that it is hoped that by the summer of 1929 power will be available for twenty Punjab towns from Gurdaspur, at a cost of ¾d. per unit.

The second stage of the development will involve the supply of current to Simla, Ambala and Patiala in the east, Gujranwala and Sialkot in the north, and Montgomery in the west. The third stage will aim at supplying Delhi, Karnal, and possibly Rohtak in the far south of the Punjab, and Saharanpur, Meerut and Panipat in the United Provinces. In its final form the scheme will supply forty-seven towns from Rohtak in the south to Sialkot in the north at an average cost of less than ¾d. per unit.

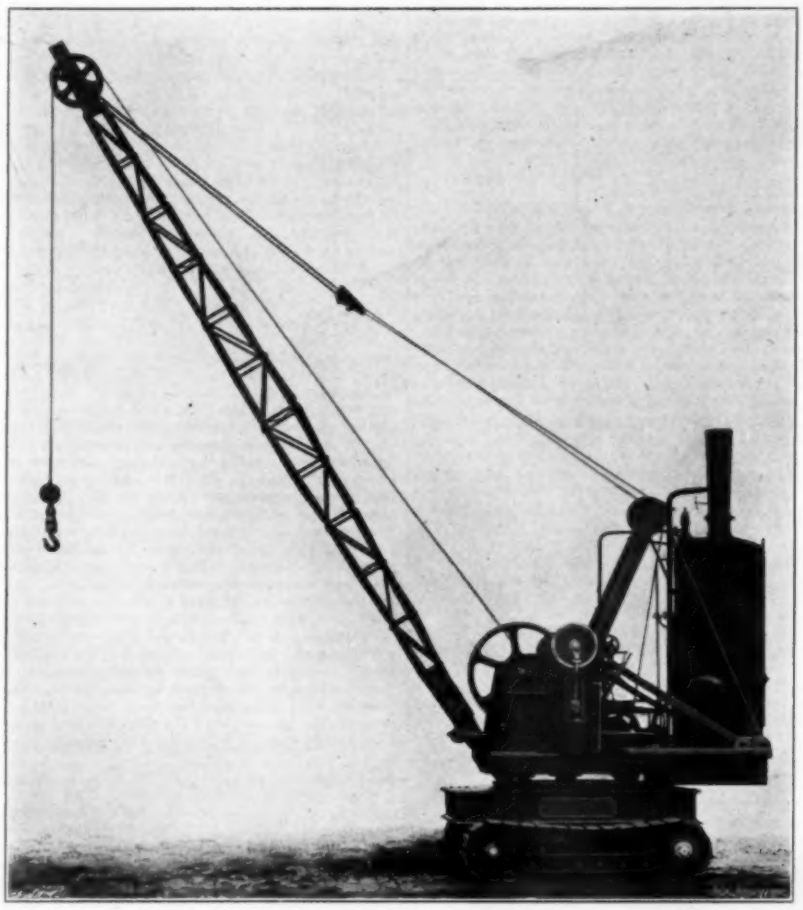
The inducements to the industrial development of the Punjab which the scheme offers are obvious. Manufacturers will be able to obtain power at relatively low cost, and later the Punjab railways can be electrified, although for many years to come the chief beneficiary will be Punjab agriculture. Authoritative inquiries, supplemented by experiments on single wells, lead to the belief that when the scheme is in operation tube well irrigation will be a business proposition at a cost of 22 rupees per acre crop per annum. Eventually no fewer than 2½ million acres of land which cannot be commanded by canals will be irrigated from this source.

Electro-farming.—Mr. R. Borlase Matthews, of Greater Felcourt, East Grinstead, much regrets to state that a fire has completely destroyed his office and with it possibly the finest collection of electro-farming data, books, photographs, catalogues, &c., in the world. He is now endeavouring to get together the nucleus of a new library and would be very grateful if readers would assist by sending to him copies of any matter or references that they may have relative to the applications of electricity to agriculture and rural electrical distribution.

Travelling Steam Crane.

In the accompanying engraving we illustrate one of a set of three travelling steam cranes supplied by Samuel Butler and Co., Limited, of Stanningley, near Leeds, for the purposes of a large contract in New Zealand. In order to permit the cranes to traverse the rough ground at the site of the works they are mounted on caterpillars, but the design is such that when the work is completed, the cranes can readily be converted to the ordinary form travelling on wheels. Before leaving the works the cranes were tested on very rough ground, and were found capable not only of turning round practically in their own length, but of carrying the full load in every position.

The cranes are worked by pairs of vertical engines having cylinders 9in. in diameter and 12in. in stroke. Steam is supplied at 100 lb. pressure from a vertical boiler 4ft. in diameter and 9ft. in height. The jib is 35ft. long, and at 16ft. radius a load of 5 tons may be lifted and hoisted at a speed of 100ft. per minute. The slewing speed is 2½ revolutions per minute, and the travelling speed 60ft. per minute. The carriage and the crab sides are of mild steel, in order to eliminate breakages when the crane has to traverse very rough ground. Four cast steel rollers working on a larger cast steel turned path support the superstructure and insure easy turning. The travelling motion is operated by means of a vertical shaft passing through the centre of the kingpost and driven by spur, bevel and sprocket wheels and chains. On the rear and driving axles clutches sliding on squares are fitted at each side in order to permit either wheel to be placed out of commission and the crane to be turned round in either direction. The bearing areas of the chain tracks are made large in order to reduce the pressure on the ground to a low value.



5-TON TRAVELLING JIB CRANE

Platinum Boom in South Africa.

(From a South African Contributor.)

The importance of the discoveries of platinum in the Transvaal is now fully realised, and the most eminent mining and geological authorities of the Union of South Africa, having investigated the discoveries, express themselves as considering that the Province should be placed foremost in the list of the world's potential platinum producing countries. Men like Dr. Wagner, of the Government Geological Survey, and Major Trevor (mining inspector), Drs. Mellor, Merensky and Cilliers (geologists), Mr. C. B. Kingston, Mr. J. E. Mills Davies, and other equally eminent consulting engineers, are among those who are convinced of the great importance of the discoveries, and of the extent and richness of the deposits, and some of them declare that a "Platinum Rand" will soon come into being, which will be of such proportions as to replace the "Gold Rand" when the latter has been worked out.

The platinum deposits in the Waterberg district were discovered about the middle of 1923, and those in the Lydenburg area during the last few months. Following them the metal has also been discovered in the Rustenburg, Middleburg and Potgieterarust districts and it is becoming increasingly evident that a very large portion of the Central Transvaal is potentially, at least, platinum bearing. It is, however, the discoveries in the Waterberg and Lydenburg districts—particularly the latter—which have brought about such a phenomenal boom that 40 companies, with capitals ranging from £100,000 to £2000, are already in existence, and more are being formed, while shares have jumped 5s. at a time and in some cases 5s. shares are now at 70s.

With regard to the Waterberg field the occurrence is so unusual that qualified mining men were not inclined to believe anything of importance had been found. However, there is no gainsaying facts, and the Transvaal Platinums, the pioneer platinum mine of South Africa, has available at date, in payable ore dumps, over 5000 tons, and, in addition, a further substantial tonnage in the mine. Values in this mine fluctuate enormously over small sections, and in order to keep a close check on the platiniferous content in development two samples are taken for each 2ft., while approximately 1400 assays are made per month. At some points phenomenally rich values have, it is stated, been found, and assays going, it is said, as high as 3000 dwts. to the ton have been obtained. At one of the 50ft. levels a value of 199 dwts. per ton over 63in. for a distance of 40ft. has been ascertained, and at another point 43 dwts. over 66in. in respect of a very substantial "run" of ore. In places a lode width of 60ft. is to be observed, although the value-carrying portion is, of course, only a fraction of that, but yet substantial, and this, combined with the facts that good values continue to be secured in depth, that there is no apparent change in mineralisation as shafts and winzes are pushed down, and that values, although essentially erratic, can be so controlled that highly payable tonnages of substantial quality are available, has placed the mine in a satisfactory position.

A power plant has been erected, but in the near future will be replaced by a much larger equipment, it having recently been decided to erect an initial reduction and treatment plant of 1000 tons per month capacity. Tests have determined the ability of a simple crushing and concentration plant embodying classifiers and Wilfley tables to extract 60 per cent. of the ore content. Supplementary to this treatment chlorination will be employed, and a total extraction of at least 92 per cent. is anticipated. The new plant will come into operation towards the close of the current year, and it is worthy of remark that the output from this mill will be the first marketing of platinum on any commercial scale by the Transvaal mines. It must be mentioned, though, that while a number of other concerns started operations on the field shortly after the Transvaal Platinum, most of them have faded away. Within the last few weeks, however, two new companies have been formed, and by means of intelligent prospecting have made discoveries of very considerable importance, which augur well for a very substantial production from the Waterberg during the next few years.

It is on the Lydenburg field that interest is chiefly focussed now, and it is there that people believe that the "Platinum Rand" will be situated. The formation has features in common with those of the Urals deposit. The first of the sensational discoveries in the hortonolite-dunite and norite beds was made about the middle of last year, but was only made public in October. Since then there have been sensational developments, culminating in the remarkable scenes witnessed on the Johannesburg Stock Exchange recently, which still continue.

Sufficient work has already been done to demonstrate the existence of a platinum belt containing at least two main payable horizons. The Lydenburg Platinums and the Transvaal Consolidated Land and Exploration Company, working in conjunction, have had spectacular developments attending the exploitation of a dunite kopje on the Ouverwacht farm, and a month ago 140 tons of rich ore had been extracted from one shaft and stacked, and it is thought probable that that ore will yield a very high content of platinum. But while the dunite may be the most spectacular of the two horizons from the point of view of pennyweights, or ounces to the ton, it is on the pyroxenite-diallage-norite zone that the bulk of hope is reposed for the establishment of an enduring platinum industry. Of this field Dr. Wagner states that outcrops of the upper or main horizon are continuous for thousands of yards, and carry from a fraction of a pennyweight to 7.5 dwt. of platinum over widths ranging from 2ft. to 8ft. "Values over considerable stretches have been proved to be fairly consistent, averaging from 2 dwt. to 3 dwt., but it is already clear that some stretches are richer than others. Careful sampling will doubtless disclose the existence of rich and poor patches, and by reason of the low average platinum content of the rock, the accurate determination of such patches will be of the utmost importance."

Dr. Wagner discusses the possibility of surface enrichment and changes in the platinum content of the norite at water level, and proceeds: "If, as it is hoped, values approximately equal to those found at the surface over certain of the stretches so far tested extend only to water level, and if but a small part of the great length over which the sheet has been traced should prove rich enough to work, there would still be enough low grade ore available on this horizon to make this part of the Lydenburg district a platinum-producing area of the first importance. Even taking the least favourable view, however, and assuming that there has been marked surface enrichment, and that the values do not go down, certain of the stretches sampled should yield a fairly big tonnage of workable surface ore."

It may be said that since this report was made the work done shows, it is asserted, that there has been little if any surface enrichment. On the Ouverwacht samples give 33 dwt. of platinum per ton. In a vertical shaft, put down 44ft., careful sampling in 12in. sections has been done. The average value to that depth was 9.8 dwt. of platinum to the ton, the average for the last 10ft. being 15 dwt. The latest assay at 42½ft. gives 17.5 dwt. of platinum per ton. It may be added that the formation has been traced for many miles.

With regard to the numerous companies formed, a number have, as in the case of those mentioned above, definite results to place before the public, but many can only say that the formation they have is similar to some of the mines which are showing good results, which statement amounts to very little. Mining authorities consider that a large proportion of these companies will die out. Unless people are prepared to go in for a blind gamble, they will await full particulars with regard to any proposition before taking shares in it.

EDUCATIONAL INTELLIGENCE.

Heat Treatment of Metals and Alloys.—An educational course, arranged for those interested in the after-treatment of manufactured iron and steel and the principal industrial alloys, especially for those engaged in the motor car, aeroplane and similar industries, will be held at the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C. 3, on Wednesday evenings from 7 to 10 p.m., beginning on Wednesday, April 22nd. The course will consist of ten lectures followed by demonstrations and practical work in the metallography and testing laboratories. The laboratory will also be open on these evenings from 6 to 7 p.m. for additional practical work. The course will be conducted by Mr. C. Coldron Smith, M.Sc., A.R.S.M., and will cover the applications of heat treatment to iron and steel and non-ferrous metals and alloys. The operations of annealing, hardening, tempering, case-hardening, &c., and the changes in properties thereby produced in ferrous and non-ferrous metals and alloys; types of furnaces and control of operations. The laboratory work will include experiments on the effect of annealing and hardening on the mechanical properties of steels and other alloys, and the metallographic examination of heat-treated specimens. Further particulars can be obtained from the Institute.

An imposing deputation of industrialists, led by the Federation of British Industries, waited upon the chairmen of the railway companies on the 7th inst., to ask for a general reduction in railway rates and charges so as to assist in a revival of industry. Sir Guy Granet, on behalf of the companies, was very sympathetic, but said that the economic position of the railways at present was not such as to allow of any reduction.

Owing to the constant danger to vehicular traffic and pedestrians caused by electric trains running through the streets of Barcelona, it has been decided to discontinue the operation of those railways traversing the city and all other level crossings. Three miles of the Sarria electric line, leading to the terminus, are to be run in a subway. The railway, which is worked by the Barcelona Traction, Light and Power Company, formerly consisted of a short line running to the suburb of Sarria, a distance of approximately four miles, but by driving a tunnel under the mountain behind the city the line has been extended to the rich valley which runs back from Tibidabo to the towns of Tarrasa and Sabadell. A Royal Decree recently issued says:—"The Municipality of Barcelona, within a period of six months, must commence the construction of a new railway, in part subterranean, with absolute suppression of all level-crossings, and complete the same within a period of three years."

Increasing the Efficiency of the Screw Propeller.*

By WALTER POLLOCK.

It is well known that the water flowing from a ship's propeller moves tangentially and axially, as in the top view in Fig. 1. The object of the "Star" contra-propeller is to convert the tangential flow into an axial flow, and so increase the propeller efficiency. This is effected by means of guide blades, which may be fixed either forward or aft of the propeller or both. These blades are so formed as to divert the flow of water as it leaves the propeller blades in a direction more or less perpendicular to the face of the

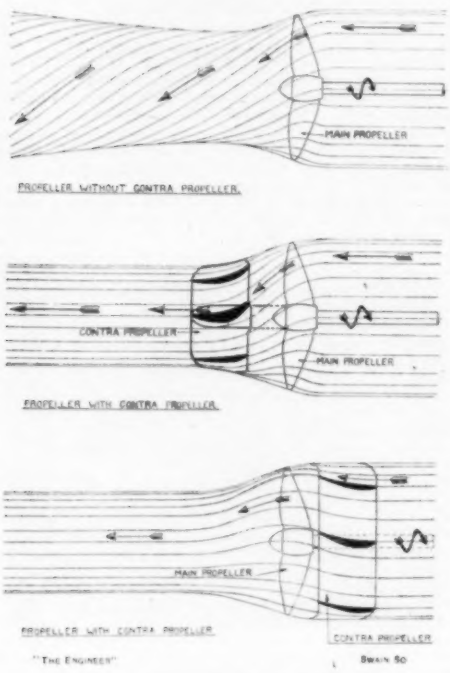


FIG. 1—PROPELLER ACTION DIAGRAMS

blade into a direction parallel to the line of the ship's course, as shown in the centre view of Fig. 1. If, however, the contra-propeller is fitted forward of the main propeller, the water flowing through its blades has its direction changed before it reaches the main propeller, as shown in the lower view of the same illustration.

The blades are so curved that just sufficient change of direction is given to prepare for and to counteract the rotary motion ordinarily given to the water by the main propeller. Since the one change of direction is just neutralised by the other, the water is thrown off the main propeller blade in a direction parallel to the course of the ship.

That the object aimed at has been achieved has now been proved, not only in experimental tank tests, but in ships in actual service. The tank tests have been carried out in the Hamburg tank, which allows models up to 40ft. in length to be run at speeds up to 33ft. per second. The apparatus allows propellers up to 24in. diameter to be tested, which adds greatly to the value of the results, as compared with the 8in. which was the original maximum diameter. The propellers are made from bronze or a special white metal, finished to their correct form by special grade moulding machines, and afterwards checked by means of accurate measuring instruments. The tank tests with the large propeller are made without a model of the hull. In the case of twin-screw ships of large size, however, it is advisable to make tank tests, both with and without the hull, in order to ascertain the effect of the stream lines caused by the stern-frame brackets and boss plating, and so enable the best form and curvature of the contra-propeller blades to be designed.

The practical results obtained in actual service from a few of the 120 ships which have now been fitted with this device are given in an appendix—not reproduced—and these go to show that there is a very definite advantage to be gained. Hitherto, however, the variations among different types of ships in coefficient of displacement, and in the formation of the stern-frame and aperture for any given tonnage, have made it difficult to ensure a uniform gain in efficiency, but recent tank experiments have furnished information which will enable that difficulty to be overcome in the future.

The "Star" contra-propeller can be built in a large number of forms, some of which are shown in Figs. 2, 3 and 4, and a great deal of the success of an application will depend upon the correct selection of the type to be adopted, which must vary according to whether the vessel is an existing one or one to be built, whether she is to have twin screws, and so on. In the case of an existing vessel, if the stern-frame aperture is wide and the propeller blades have very little set-back, so as to give a good clearance between the after edge of the propeller and the forward side of the rudder post—type Ib, Fig 4.—with only four blades, will in most cases be the best. Where the available space is small—type Ia, Fig. 2—will be preferable, in order to obtain the increased surface provided by that design.

For a new single-screw vessel the type illustrated by Fig. 5, in which the vertical blades are solid with the rudder post, should be adopted, while if the stern post be suitably forged, or, alternatively, the stern plates of the hull carried aft and suitably shaped, all the advantages of type IIIb—Fig. 4—could be obtained with the least increase in cost.

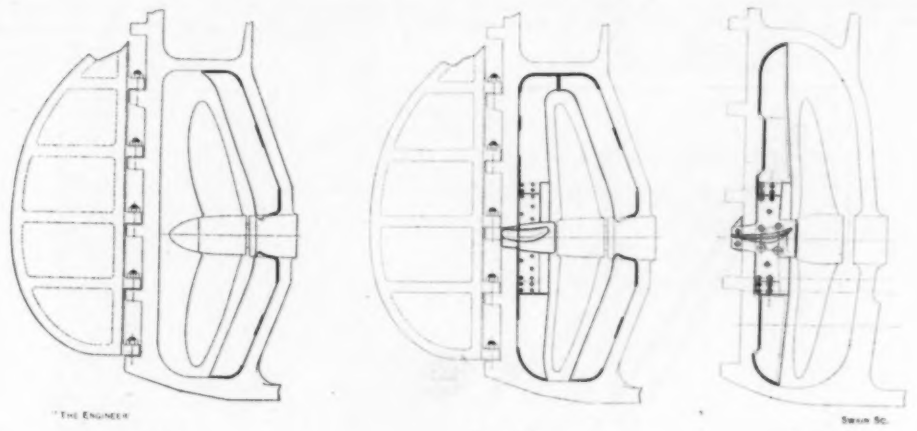
In the case of a new vessel of the single-screw mail-passenger type with fine lines, the most satisfactory selection would be type IIb—Fig. 3. With existing twin-screw vessels the fin or blade outside of the boss plate means an additional attachment, but in the case of new vessels it is comparatively simple and inexpensive to shape the propeller shaft bracket or the stern tube boss plating to form the necessary blades, and in the latter case the plating may also be extended to form the outer blade with a minimum of difficulty. In the type illustrated in Fig. 5, designed by the author, the vertical blades are forged solid with the rudder post, thus dispensing with welding and reducing the weight and cost. In this arrangement, the fore and aft dimension of the rudder post is increased to give the necessary area and form the required curvature in the original forging. At first, this may appear somewhat difficult, but on close examination the total cost would be found to be no more than that of special forgings on stems and other parts for the same relative weight. If sufficient width could be obtained, it might prove possible to adopt these vertical blades alone, and dispense entirely with side blades.

An interesting proposal is that of Mr. E. W. Harvey, who suggests a casting to ship over the rudder post—see Fig. 6. The object is to do away with welding entirely, and its concomitant cost and expenditure of time.

In general, the dimensions of a contra-propeller are governed by the dimensions of the main propeller, the stern-frame aperture and the indicated horse-power, which must vary considerably with the type of ship and the particular views of its designer. For this reason, it is impossible to standardise the device as regards dimensions and weight, and each case must be dealt with independently.

Some of the early forms of type Ia—Fig. 2—were designed and constructed after careful calculations had been made of the various stresses due to the water leaving the main propeller, and these showed that the root section of the side blades was amply strong in smooth water. In several cases, however, they proved to be too weak to stand the pressures in a heavy sea, especially those blades with a concave surface on the underside, and several were found broken. Whilst the calculations were being overhauled and the root section of the blades increased, tank tests proved that by slightly increasing the area, one blade on each side was almost as efficient as two. This reduction in the number of blades enabled the single blade to be made thicker and stronger, and partially solved the problem of weight.

The natural evolution in that direction will be found in the later designs—for instance, type IIa, Fig. 4—consisting of vertical blades only, forward of the main propeller, is of the lightest possible construction, and when incorporated with the hull plating has little or no additional weight, compared with the ordinary ship construction without a contra-propeller. In the case of twin-screw vessels with plated bosses to carry the tail shafts, a contra-propeller can be formed very easily by extending the plates to form the curved vanes or blades necessary to deflect the flow of water to the propellers. This method only slightly increases the weight.



Type IIa Type IIIb Type Ib

FIG. 4

In addition to the gain in efficiency, there are a number of minor advantages to be obtained by fitting a "Star" contra-propeller. Improved steering is obtained, and pitching and rolling is reduced when side blades are fitted, with the result that better sea-going qualities in head seas are obtained. In several of the vessels fitted with the device, the advantage has been considerable, and in one case it has been stated that the increased speed in a heavy sea was 1½ knots. Vibration also is reduced, as the water is less broken, and in geared turbine vessels the torque variation in the shafting is reduced by a contra-propeller; whilst several of the types with side blades are a distinct protection to the main propeller against damage by small craft or any floating or partially submerged objects, as the obstruction would be met by the fixed contra-propeller instead of by the main propeller, and the ship could still continue her voyage in a satisfactory condition.

Accompanying this paper are two appendices, the first of which contains a series of test results taken on actual sister ships operating under similar conditions. These include the motor vessels Silverlarch and Silverpine, one with and one without a contra-propeller—see Fig. 2—the Thuringia and Westphalia, the ss. Neptune, the Norfolk and Norfolk Maru, the Andalusia and Arabia, the Kong Helge, the Vestri and Austri, the tug Stecknitz and the river tug, the propeller of which is illustrated in Fig. 3. For all these vessels test figures and curves are given. In the second appendix the mathematical basis of the contra-propeller theory is discussed.

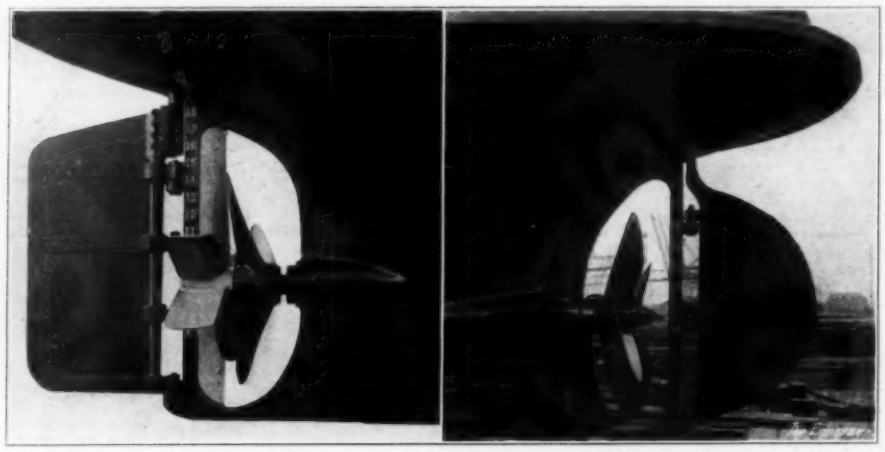


FIG. 2—TYPE IA ON THE SILVERLARCH

FIG. 3—TYPE IIB ON A RIVER TUG

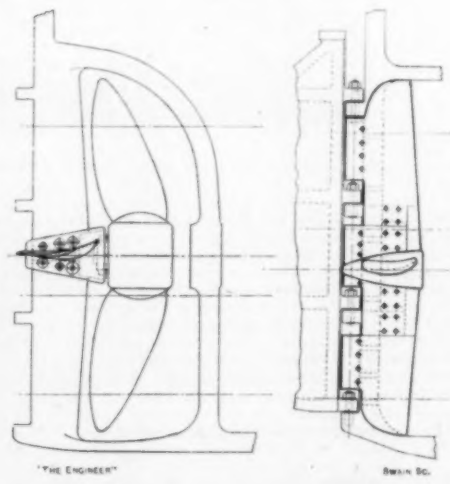


FIG. 5 FIG. 6

* Institution of Naval Architects, April 2nd, 1925. Abridged.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(*From our own Correspondent.*)

Trade Situation.

Many of the Midland works have been idle the whole of this week, and iron and steel mills in Staffordshire have, for the most part, taken a full week's holiday. The holiday influence was very noticeable at this week's meeting of the Midland iron trade at Birmingham. There was a poor attendance, and the amount of business transacted was negligible. Little call for material was to be expected in the present unsatisfactory state of works order books and of trade conditions generally. Iron and steel masters are getting very anxious as to the future. The new quarter has not added impetus to trade, which is as lifeless as ever, and in no direction can producers discern actual signs of improvement. The immediate future is being approached with hesitancy, neither producer or consumer being prepared to commit himself forward. Values are irregular, quotations being shaded to meet individual cases. The trade situation, taken as a whole, is a most involved one.

Staffordshire Bar Iron.

Black Country ironmasters are badly off for orders in the majority of cases. The makers of marked bars keep rigidly to the long-established price basis of £15; but some of the quotations for medium and common grades of finished iron are shaded in varying degrees, as may be dictated by the individual circumstances of sellers. The inroads which the competition of steel, foreign and native, is making in the finished iron branches, leaves many of the mills with order books almost bare. Values are generally too high, based on production costs to admit of any recovery. Lancashire Crown bars have been lowered to £12 5s. for export. Belgian shippers have reduced their quotation for common bars to £7 7s. 6d., which compares with £11 15s., the price nominally ruling for South Staffordshire nut and bolt bars.

Raw Iron.

Pig iron values are weak and, with demand poor, no one seems disposed to book or place orders of an account far ahead. Stocks are low, and though prices are generally considered to be at rock bottom, there are smelters who still shade the quotations nominally ruling. Following the weakness in the North of England, Northamptonshire iron has, in a few cases, been "cut" below the £3 12s. 6d. basis, but £3 17s. 6d. is a firm figure for Derbyshire. The market has been extremely quiet this week on account of the holidays, and the few transactions which have been put through were not of any magnitude. The demand for foundry iron is probably not less than it was a few months ago. It falls short of supply, however, and in these circumstances neither customers nor merchants will buy outside immediate requirements. There are exceptions which crop up now and again, but, as a rule, speculative enterprise is absent. Forge material is rarely called for in anything but the smallest quantities, and the sales are insufficient really to test prices. Consumers express doubts as to whether the market has yet touched bottom.

Keen Competition in Steel.

The irregularity of steel prices illustrates the keen competition for an inadequate volume of business. A slight improvement is reported in business in sections, the generally quotation being about £8 15s. Small steel bars can be bought without difficulty at £8 15s., and soft billets at £6 17s. 6d. to £7. Constructional steel is in good demand, an increasing number of engineers being well placed for the next three months. As far as this district is concerned, this business has been obtained in spite of the fact that steel plates here cost £9 15s., as against £8 17s. 6d. in the North of England. Midland engineers have to depend almost wholly on home business, being out of the running on foreign contracts. Appeals have been made to steel makers to correct this disparity, but so far with little encouragement. It is hoped, however, that some concession may shortly be made. The makers of axles and tires for railway work are fairly busy, and orders in connection with the new Australian cruisers are beginning to reach the heavy forgers and founders. Rail orders are scarce and are much wanted. Continental producers offer supplies at prices below the home cost of production. Conditions prevailing in the import market are fairly steady. Belgian billets have hardened a little to £6 6s., but with British billets at £7, this leaves a sufficient margin to divert business. Steel scrap is selling a little better, but difficulty is commonly met with through the refusal of buyers to take deliveries.

Galvanised Sheets.

The recently developed strength in the price of galvanised corrugated sheets is maintained; an average price for 24-gauge is £16 10s. f.o.b. A few makers ask half-a-crown above that figure for district delivery. These works have business in hand for some months to come. The tin-plate trade has a more favourable outlook with better contracts from the Far East.

Bilston Furnace Damped Down.

The unsatisfactory state of the steel trade is reflected in the damping-down of another furnace at Messrs. Alfred Hickmans steel works, Spring Vale, Bilston, involving the suspension of 35 workers. It may also be taken as an indication that immediate prospects are in no sense encouraging. The stoppage of this furnace is a misfortune to the district following the recent closing down of large mills. It is hoped that as soon as there is an improvement of the iron and steel trade it will be possible to restart the furnace. There are now only three furnaces blowing at the works.

Rolling Stock Order.

Additional work continues to be secured by Midland rolling stock establishments. It is understood this week that a contract for one thousand covered wagons for the Egyptian State Railways has been divided between the Metropolitan Carriage, Wagon and Finance Company, Ltd., of Saltley, Birmingham, and the Ringhofer Works of Czecho-Slovakia.

LANCASHIRE.

(*From our own Correspondents.*)

Manchester.

General Outlook.

Business men in Manchester come back very slowly to work this week. They seem to be rather like Shakespeare's schoolboy, "crawling, like snail, unwillingly," to the markets, and one cannot be altogether surprised, for there is little to come for this week, and apparently no expectation of any sudden change in prices, or any very urgent accumulation of orders. There ought, of course, to be an improvement in the volume of business between Easter and Whitsuntide, but it will scarcely be visible this week. The position with regard to foreign business and the exchanges in France and Belgium is still uncertain. The recent drop in the value of francs seems to be arrested for the moment, but it has enabled merchants to offer foreign material on easier terms, and the difference in prices is already far too great. Manchester has felt this competition, particularly in bar iron, and one does not hear that the recent "propaganda" campaign of the Lancashire bar iron makers has done much good.

Metals.

The markets for non-ferrous metals are in a state of very great uncertainty, and merchants and consumers here do not know what to think. At the beginning of the year it was very generally believed that copper could not fall to lower prices, or, at any rate, not beyond a pound or two a ton; but the view in this respect has changed, and some people here are arguing that there is nothing to prevent a further fall. Of course, we know that certain copper-producing concerns can obtain a large profit even when the selling price is much below £60 per ton for standard. The Rio Tinto Company is one of them, and there are four or five American companies, the actual producing costs of which would allow of a very low selling price. People argue therefore that a further fall would not check production. On the other hand, there are producers who cannot make any profit when prices are low, and the question is whether those producers whose costs are low can turn out as much copper as the world now needs. It is a very difficult question, and one about which it would be rash to dogmatise. The consumers here seem to think that in the present state of the market the safest course is to buy only what is wanted for immediate consumption, and to work upon low stocks. This policy of itself will tend to keep the market down, so long as the output of copper remains anything like as large as it has been during the last few months. The actual figures relating to the production of copper in January and February show a reduction in the latter month of about 6000 tons, or roughly 5 per cent.; but it merely corresponds with the difference in working days between the two months, and one doubts whether any active steps have yet been taken to curtail the output. The market here for scrap copper, gun-metal and yellow brass is in a very depressed condition, and many dealers are reducing their prices. Gun-metal is particularly depressed, and is difficult to sell unless some guarantee as to the mixture can be given. For a known mixture a fair price can be obtained, but unfortunately most lots of scrap gun-metal are of various mixtures, and no guarantee can be given. The market for tin is still very variable and uncertain. The general tendency, of course, has been downward for some time. Unlike copper, there is plenty of margin for a fall without coming anywhere near the costs of production. Consumption is fairly good, and so far as one can see there has been no expansion in the supplies, and hence it is not safe to assume that the fall must go much farther. Lead and spelter have been rather weak, but the latter is now at a fairly reasonable price.

Pig Iron.

The market here for foundry iron is almost without business this week, but as it is hoped that buying will revive next week, sellers are keeping to the old prices. It may be that some orders will have accumulated, and, if so, this will give an air of activity to the market for a time; but it is fairly clear now that the output of pig iron in the Midlands, reduced as it has been by the putting out of furnaces, is yet too great for the present consumption. Makers of Derbyshire pig iron still base their Manchester price for No. 3 on 77s. 6d. per ton at the furnaces, and say that it is impossible to come down any more until the costs of production are lessened; but buyers point to the fact that Northampton furnaces can make No. 3 pig iron at 72s. 6d., and it is difficult to get them to believe that 77s. 6d. can be a rock-bottom price, either for Derbyshire or for Cleveland iron. In any case, there is no disposition on the part of consumers to lay in stocks of foundry iron at these prices, and so far as can be seen the practice of buying from hand to mouth is likely to be continued. There is no improvement yet reported in the foundry trade of the district, and the same keen competition for orders for castings continues, practically forcing the utmost economy in the buying of pig iron and scrap.

Steel.

The market for manufactured steel remains dull and lifeless, and business here is reduced to a minimum. There is no definite alteration in the nominal prices, and so far the Midland makers do not follow the example of the North-Eastern district in the matter of steel plates. Of course, there is no shipbuilding, and the concession in the Cleveland district was ostensibly to give the shipbuilders a better chance of competing for orders; although it will take a good deal more than that to render British shipbuilding safe from continental competition. In the end, this industry must go to the countries where steel is cheapest, and where men will work longer hours for the same pay. Nominal prices for steel here are £8 10s. to £8 15s. for joists and angles; £9 15s. for plates; and £9 5s. to £10 5s. for bars. Bar iron of local make is neglected, but the price is still £12 10s. per ton.

Scrap.

The depression in the steel scrap market is unabated, and dealers are very uncertain at what price they ought to buy. One hears occasionally of 60s. per ton on trucks for melting scrap, but as a rule 57s. 6d. is offered, and it is still hoped that when the Sheffield buyers come in again a profitable outlet will be found. The weakness in the steel-making pig irons is, however, a sure indication of the state of the steel trade. Heavy wrought scrap is steady at 80s. to 85s. per ton. Cast scrap is rather neglected at the moment, and the prices vary from 77s. 6d. up to 85s., according to quality.

Institution of Civil Engineers.

The annual general meeting of the Manchester and District Association of the Institution of Civil Engineers was held in Manchester on the 8th inst. The annual report, which was presented, states that the membership is now 411. Professor A. H. Gibson, of Manchester University, was elected President for the forthcoming session, succeeding Mr. G. G. Lynde. Mr. H. Mattinson was re-elected honorary treasurer, and Mr. A. C. Dean and Mr. C. Peel were elected honorary secretary and assistant honorary secretary respectively. At the conclusion of the formal business a paper was read by Mr. P. W. Bertlin on "The Construction of the New Entrance to Tranmere Dock," belonging to Cammell Laird and Co., Ltd., Birkenhead. The work of construction was dealt with under the following headings:—The construction of the main cofferdams, the construction of the work enclosed by the existing river wall and the cofferdam, the removal of the length of river wall in front of the site of the new entrance, the launching and floating of the new caisson, the removal of the main dam, and the closing of the existing 90ft. entrance and completion of the caisson chamber. The work was carried out during the late war by Messrs. Edmund Nuttall and Co., to accommodate the wide-beamed battleships. The scheme provided for the elimination of the two existing entrances and the construction in their place of one entrance with a clear opening of 140ft. and a depth from high water to sill of 38ft. 10in. at high water ordinary neap tides, closed by a rectangular steel caisson 145ft. long by 26ft. 9½in. wide by 42ft. 9in. deep.

Barrow-in-Furness.

Hematite.

The usual holiday quietness has been experienced in the hematite pig iron trade, but it is hoped that more life will be manifested in the next week or two. Apart from the holidays, the trade has become very quiet, and but for the continuance of the steel departments at Barrow and Moss Bay, there would be an immediate curtailment of output. There are still thirteen furnaces in blast, but makers are experiencing difficulty in clearing their products. None of the buyers are showing any inclination to place orders for heavy tonnage or to indulge in the placing of orders for forward delivery. There appears to be little desire to go beyond immediate requirements, which at the present time are only small. Scotland is not taking what it did and the same remark applies to the Midlands. A certain amount of pig iron is going into Wales, but the quantity is not by any means large. Continental business is very slack, and the trade with America cannot be relied upon. Information from various centres is to the effect that engineers are not busy, and are not requiring heavy deliveries of pig iron. Special qualities of iron are not in much demand.

Iron Ore.

The iron ore trade is about the same. Its condition is simply a reflection of the iron trade. There is not much going out of the district. Foreign ore is arriving in limited quantities. Some of the mines are contemplating applying to the Barrow Corporation for a supply of electricity for pumping. One mine has already installed it, and it is giving very economical results.

Steel.

The steel trade continues to be quiet. The rail mills at Moss Bay are not working regularly. They hold a few orders. The market is dull and competition is heavy. Foundries are moderately employed. Vickers Ltd. are stated to have taken over the foundry at Ormsgill, which was started during the war. Ormsgill is on the outskirts of Barrow, and not far from the Barrow Hematite Steel Company's works.

Electricity.

The Barrow Corporation, having obtained powers to do so some time ago, has now completed the running of overhead high-tension cables from Barrow to Ulverston. The transformer house is nearing completion, and soon Ulverston will be in a position to use electrical energy for industrial and domestic purposes. It is believed that many firms will install it. The Backbarrow scheme for putting down three 500-kilowatt turbo-generators just below the falls is progressing slowly. The Fishery Board's objections have been practically met, but the proposals require confirmation. When this installation is complete, it will link up with the Barrow supply on the west shore of the river Leven. It is understood that the laying of the cable from this spot to Grange will be proceeded with shortly, and thus Grange will also come under the scheme. I understand that the Barrow paper mills have contracted with the Barrow Corporation to take the whole of the power required from the Corporation, which will amount to a very big quantity in the year. The Barrow Corporation electricity undertaking seems to be making very rapid headway, and it may lead to much-needed cheaper power being obtainable in the town.

SHEFFIELD.

(From our own Correspondent.)

State of the Steel Trade.

This week has been a broken one in the steel trade, and there is nothing new to say with regard to its condition. On the basic side the depression is as severe as ever, and not only is there a great shortage of orders, but the inquiries which have come to hand recently have been on a negligible scale. The acid steel departments are better employed, chiefly on railway work, but the large contracts for the home companies are being rapidly executed, and are not being fully replaced. There are on hand some special engineering contracts of considerable value, but the trade generally is quieter than of late. The shipbuilding yards are making but poor demands on Sheffield, although there are one or two signs of improvement in this trade. The downward tendency in the prices of iron, steel and scrap material continues. Authorities on Sheffield trade are still disinclined to take a pessimistic view of the future, but there appears to be little hope of any material change during the present year.

The Lighter Side.

Although the finished branches of local industry are moderately employed, with here and there a busy department, the conditions are not at all as good as could be desired. In most branches there was a decline in turnover a couple of months ago, and the lost ground has not yet been recovered. The cutlery trade shows no improvement. A falling off in the demand for stainless steel table knives is still noticed, although the total production remains at a considerable level. Australia is not buying cutlery as freely as she did last year, and there has been a decline in exports to several other markets. Some of the electro-plate firms have very useful orders on hand for table equipment.

Furnace Building Contracts.

The firm of G. P. Wincott, Ltd., engineers and furnace designers, of Sheffield, which specialises in industrial furnaces of every type, and which is also largely engaged upon equipments for metallurgical use, has recently secured several good contracts from the sugar-beet and other industries. It is supplying the West Midland Sugar Company, Ltd., and the Anglo-Scottish Beet Sugar Corporation, Ltd., with the furnace equipments required at the factories which are now being built at Kidderminster, Spalding and Colwick. It is also installing pulverised coal-fired furnaces for F. R. Simpson, Ltd., Oldbury, and Charles Roberts, Ltd., Horbury Junction. For the Electrode Company, Ltd., Sheffield, it is building a special producer gas-fired ring-type electrode furnace to be used for the manufacture of electrodes for electric furnaces. Soaking pits are being installed for John Brown and Co., Ltd., Sheffield; and combustion chambers for pulverised coal-fired boilers have just been completed for the West Bromwich Corporation and for Newton, Chambers and Co., Ltd.

A Works Not to Close.

I recently reported the purchase, by Thos. W. Ward, Ltd., Sheffield, of the goodwill and business of George Cooper and Sons, Ltd., Effingham Nut and Bolt Works, Sheffield. At that time the hope was expressed that Messrs. Ward would be able to avoid the closing of the works. Now the announcement is made that, in view of the urgent need of employment in the city, and with a desire to continue an old established firm, Messrs. Ward will reorganise and carry on the business under the name of George Cooper and Sons. The works have had a wide connection in the past, and with increased and improved means of production, they should add to their former reputation.

Colliery Developments.

Projects for the further development of the coalfields continue to be brought forward in both South and West Yorkshire. The scheme for boring at Barnby Moor, five or six miles south of Bawtry, in the Doncaster district, has made progress. The contract has now been let to a Belgian firm, the Forsky Company, of Brussels, and the work is to be begun immediately. Great quantities of piping and machinery to be used in the operations have already arrived from Belgium, and are being taken to the site of the new colliery. The land under which coal will be worked belongs chiefly to General Denison, late of Babworth Hall, and a lease of a considerable area has been obtained by James Nimmo and Co., Ltd., by whom the pit will be sunk. At a water supply inquiry by the Ministry of Health at Doncaster last week, reference was made to the fact that the Markham group of collieries intended to sink a new pit at Awkley, which would mean the building of a colliery village with a population of from 5000 to 10,000 people, and that a colliery village of similar size was to be erected at Micklebring, a few miles from Doncaster.

Reaching the Lower Beds.

Stewarts and Lloyds, Ltd., iron and steel tube manufacturers, of Birmingham and Glasgow, who are now the owners of the Kilnhurst and Swinton Common Collieries—formerly the property of J. and J. Charlesworth, Ltd.—are taking energetic steps to deepen the pits, so as to reach additional beds and to secure an increased output. Both the collieries are of considerable age, and their joint production, at present, is about 6000 tons per week. At Swinton, where only the Barnsley bed is now worked, sinking and drifting operations to the Haigh Moor are being carried out. At Kilnhurst, both the Barnsley and Haigh Moor seams are already worked, and the object of the deepening operations there is to reach the Parkgate, and eventually the Silkstone. The upcast shaft has now reached a depth of about 650 yards, which is within 40 yards of the Silkstone coal. Great improvements are being carried out on the surface, where the plant is to be completely remodelled, and electrified with power generated on the premises. Coke ovens of the latest type are to be erected, and also a brick-making plant of large capacity. The products of the latter will be used in the building of houses for the workpeople, who now number 1200, and who are expected to increase by 2000 when the developments are completed. It will take a couple of years to carry out the extensions, and at the end of that time an output of 4000 tons a day is looked for.

Doncaster Water Schemes.

The water inquiry at Doncaster, to which reference has been made above, related to an application by a Joint Water Board of Doncaster and Tickhill, for new borrowing powers for £9000. A large scheme is in contemplation for the supply of water to several parts of the district, and the total cost, originally put at £128,200, has been increased to £137,200. The additional items, for which sanction was sought last week, are £6850 for laying the main through Bentley and Arksey urban district, and £2150 for laying a main through the street at Norton. There has also been an inquiry into an application by the Doncaster Corporation for sanction to borrow £12,177 for the purpose of putting down an 18in. water main from the Nutwell borehole and pumping station to a proposed water tower in Church-lane, Cantley. The plans for the tower are being prepared, and the application for further borrowing powers will be submitted to the Ministry as soon as these plans are completed.

A Scarborough Disappointment.

Great regret is expressed in Scarborough at the very limited extent to which the Government is prepared to support a project for the improvement of the harbour. The Harbour Commissioners desire to deepen the harbour over a certain area by 3ft., which would be a great advantage to the fishing industry and to shipping generally. The estimated cost is £45,000. It was hoped that a third of this sum would be given by the Development Commissioners, and that the Scarborough Corporation would provide another third, and would also guarantee a loan of the balance to the Harbour Commissioners. When representatives of the local authorities interviewed the Development Commissioners, however, they were informed that the Government was not prepared to make a grant, but that the Treasury would be recommended to make a loan of £15,000, free of interest, for ten years, after which interest would have to be paid. The matter will now have to be considered very carefully by the Town Council and the Harbour Commissioners. There is a feeling at present that the decision places the deepening scheme in jeopardy.

A Railway Order.

At the annual meeting of Cammell Laird and Co., Ltd., a week or two ago, the chairman was able to make the gratifying statement that the Leeds Forge Company, one of the company's subsidiaries, had done much better during 1924 than during 1923. It is now announced that the Forge has received an order from the Crown Agents for the Colonies for 100 all-steel bogie covered goods wagons for the Uganda Railway. This type of wagon was originally designed by the Leeds Forge Company, and the present order is the eleventh which it has received since 1912.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron Trade.

The Cleveland pig iron trade presents few new features of moment. The Easter holiday season has had a restrictive influence upon the already limited volume of home business, and whilst there are some signs of improvement in the export branch of the trade, the French financial crisis is a disturbing factor. Still, it is a fact that Cleveland prices are now down to a competitive level with continental quotations, and as these latter are below cost, it scarcely seems possible that they can fall much further. Rather will producers incline to further restrictions of output if present prices cannot be maintained. At the same time, the statistical position of the trade is such and stocks in makers' yards are so low, that little improvement in the demand is needed to strengthen the market. Prices are unchanged, No. 1 being 82s. 6d., No. 3 G.M.B. Cleveland 77s. 6d., No. 4 foundry 76s. 6d., and No. 4 forge 75s. 6d.

Hematite Pig Iron.

There are no indications of any improvement in the East Coast hematite pig iron trade. The demand for this period of the year is very disappointing, and consumers are still showing little inclination to place orders for metal, except for small tonnages to cover their immediate needs. Although production has been considerably curtailed since the beginning of the year, stocks in makers' yards are reported to be very heavy, and a good steady trade would be welcome. There are now only twelve furnaces on the North-East Coast producing hematite. The market quotation for mixed numbers is no more than 82s. 6d. per ton, and 83s. for No. 1 quality.

Ironmaking Materials.

Dealers in foreign ore are experiencing a difficult time. The market continues dull and featureless, and consumers, who have fairly large stocks on hand, show little or no disposition to place new orders, being prepared to adopt a waiting policy until the iron trade position improves appreciably. Best Rubio ore is purely nominal at 22s. c.i.f. Tees. There is scarcely any demand for blast-furnace coke at 22s. 6d. per ton delivered at the works.

Manufactured Iron and Steel.

There is still no evidence of animation about the manufactured iron and steel trade. The recent reductions in prices will enable engineers and shipbuilders to quote more keenly for new work, and to that extent are bound favourably to affect the ultimate demand, but such influences have not yet been perceptible, and specifications to manufacturers are still coming along in hand-to-mouth fashion. The only busy branch of the industry is the galvanised sheet trade, and some large orders have been secured recently, both on home and export account. The price of galvanised sheets of 24 gauge is firm at £16 10s., and black sheets command £11 15s. per ton. Other prices reveal no variation.

The Coal Trade.

Conditions in the Northern coal trade are very discouraging. The prevailing quietness on the market has been accentuated this week, owing to the holidays, and little interest has been taken in the position. Business in all branches tends to contract rather than to expand, and prices are difficult to maintain, notwithstanding that the output has been considerably reduced by the closing of pits and the working of short time at others. The home trade is dull, with the demand inclined to diminish, as is usual at this period of the year in the case of fuel for utility work and household purposes. In the export branch it is difficult to secure orders in the face of heavy stocks, which, it is understood, are held abroad, and competition on the part of Germany. The marked falling off in the coal export trade is reflected in the shipments from the Tyne during March, which showed a decrease of 437,322 tons, as compared with the same month a year ago, when the total reached 1,792,938 tons. In the first three months of this year the shipments totalled 4,155,393 tons, or a decrease of 1,098,729 tons on the first quarter of 1924. The coke trade is in a lifeless condition. Stocks are large and buyers very scarce, and all prices are weakly held.

Blast-furnacemen's Wages Unchanged.

In accordance with the quarterly ascertainment issued this week, the wages of blast-furnacemen on the North-East Coast will remain unaltered during the next three months. The certified net selling price of No. 3 Cleveland pig iron for the past quarter was 78s. 6.87d. per ton.

SCOTLAND.

(From our own Correspondent.)

Trade Outlook.

The depression in trade circles continues at an acute stage, and latest opinions reveal a considerable amount of pessimism regarding the immediate future. The annual holiday season will be upon us in a little over two months' time, and there seems small hope of any improvement within that period, and it seems extremely doubtful if the autumn will witness any forward movement either. Conditions have gradually become less and less satisfactory, until now in many branches of industry it is simply a case of "hanging on" in the hope that something will soon turn up to change the course of trade. Every week now brings either definite news or rumours of a further curtailment of activities in some department, with practically no improvement in other directions calculated to make good the loss incurred. The outlook from now until the holidays is decidedly bleak, and it is fervently hoped that a marked improvement will usher in the early autumn.

Pig Iron.

The home and export demands for pig iron continue on a very poor scale, and at the works where furnaces are still in blast stocks are increasing. Prices are still weakening, and it can only be a matter of time until the production will be a negligible quantity.

Steel.

So far as the market for plates and sections is concerned, conditions are as near stagnation as is possible without bringing a stoppage. Demands from shipbuilding yards and engineering works are most disappointing, the price of the home product being evidently too high to merit consideration. Some makers have comparatively good orders for rails for home use, but on the whole the works are greatly in need of specifications for all classes of material, with the exception of sheets. The last-mentioned are busier, especially in light varieties. Galvanised sheets are now in as extensive demand as in pre-war days, and there is apparently less price-cutting indulged in.

Iron.

Reports from all quarters indicate a dearth of fresh business on either home or export account. The demand for re-rolled steel has been a shade better, and has provided work to enable the mills to preserve a minimum rate of employment. Prices have had to be severely cut, however, to secure this business. There is practically nothing being done in scrap material at present.

Coal.

The depression in the coal trade has hardly ever been more oppressive than at present. Despite all efforts to relieve the position, the collieries in all districts find great difficulty in securing fresh business for export. The competition from continental sources continues most severe, and though exporters have on occasion cut prices to a considerable extent, very little success has attended their efforts. Many pits are idle, and at those still in operation idle time is fairly prevalent. In round coal, Lanarkshire splints and Lothians steams alone maintain a measure of firmness, and in the case of the latter this is due chiefly to the decreased output. Washed nuts, too, are a shade firmer, owing to smaller outputs, but pearls, drosses, and other materials are decidedly weak. The home market is slackening off as the season advances. Municipal and household requirements are shrinking, while industrial demands remain far below normal.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

THE conditions in the steam coal trade of this district have naturally been very quiet during the past week, for the reason that holidays have taken up such a large part of the time. The miners worked on Good Friday, but this week work was not resumed until the night shift on Wednesday. At the docks there was no work on Good Friday, but a restart was made on Wednesday morning. So far as the commercial side of the industry is concerned, it is pretty correct to say that business has been at a standstill since the middle of last week, while practically nothing has been done this week, owing to fresh business being so restricted, and to the fact that most exporters had made their arrangements last week for coal supplied for shipment by steamers expected to be ready immediately after the holidays. Both shipowners and coal exporters made big efforts to get vessels loaded and dispatched before the vacation, in order that tonnage should not be detained for such a long period in dock, and they were very successful, as may be gauged from the information that on Saturday morning there were no less than twenty-five loading berths idle at Cardiff, Penarth and Barry, whereas only three steamers were waiting to load. Hopes were entertained that arrivals of tonnage over the holidays would be on a sufficiently heavy scale to make up for the substantial exodus of loaded boats, but while the quantity of tonnage is moderately good, it is questionable whether it is equal to providing collieries with anything like enough to make shipments sufficiently active to enable the pits to work regularly for any length of time. The demand for coals for shipment during the second half of the month has been restricted, and it looks very much as if the conditions will continue to be quiet. As regards the recent inquiry from the French Marine for a substantial quantity of patent fuel and coal, it is understood that only about 1500 tons of coal have been placed in this district, and that the balance of the business has gone to French manufacturers of patent fuel. In the case of the anthracite collieries, it is fully expected that from now on they will be fairly busy as the result of the substantial shipments which have to be made to Canada. Already two or three ships have been loaded and have sailed for Montreal and Quebec, and other steamers are due to take in cargoes for the Dominion. The quantity of Welsh anthracite which will be shipped to Canada this season will be materially in advance of the quantity despatched in former years, and there is every indication of this trade displaying further expansion.

Increasing Unemployment.

The depressed state of trade is responsible for the closing down of more collieries in this district. On Wednesday of last week the men employed at Nixon's Navigation Colliery, Mountain Ash, received a fortnight's notice to terminate their employment. The number of miners affected is about 2500, the majority of whom have had very little work for some time past. The Rhondda district, which has suffered very considerably as the result of the Cambrian pits being closed since last August, has received further blows, inasmuch as 1200 miners employed by Messrs. Cory Brothers at their Tydraw Colliery, Tynewydd, are under notice, while notices expire this week in the case of about 1000 men working at the Abergorchy Colliery of the United National Collieries, Ltd.

Vauxhall Miners' Experiment.

The experiment on the part of the miners at the Vauxhall Colliery appears to be working out very satisfactorily, as, since the scheme came into operation, the men have lost no time and therefore the guarantee fund, now amounting to £700, has not been drawn upon. Apart from the colliery working full time, the men appear to be very satisfied with the new conditions, more especially as they are earning better money. Only a few of the coal-getters are on the minimum of 9s. 5d. per day, while others have been earning on the average 12s. to 14s. per shift, and in some instances as much as 18s. per day. The output of the colliery has considerably improved, and it will be interesting to see what comes of the proposal to expel the men from the union. At the last meeting of the North Wales Miners' Association nothing definite was decided on this point, except that counsel's opinion should be taken on it. The miners at the Vauxhall Colliery not only have the sympathy and support of the public in that district, but of many miners working at other collieries in the district who have contributed to the guarantee fund.

Trouble in Milling Industry.

A fairly large number of men and girls are engaged in the milling industry at Cardiff and Barry, and unfortunately there has been trouble of late, with the result that about 1000 men and girls have been idle at the mills in those towns. The dispute arose out of the action of one firm in "standing off" two employees as a means of working short time at the mills. This was met by the employees with an embargo on all overtime, and very soon, acting on the policy of "all in or all out," the workmen and girls at other mills came out on strike on Wednesday and Thursday of last week. Since then negotiations have been taking place in London between the officers of the Workers' Union and the officials of the Flour Milling Employers' Federation, and hopes are entertained that before the end of the week an arrangement will have been made that will enable a resumption of work to take place.

Death of Mr. Alfred Cox.

The death took place with unexpected suddenness at his home at Dinas Powis, near Cardiff, of Mr. Alfred Cox, the general manager of the Cardiff Channel Dry Docks and Pontoon Company, Ltd., and its subsidiary undertakings, which form one of the largest combinations in the ship-repairing industry in South Wales. Mr. Cox, who had been slightly indisposed, though not to an extent to cause anxiety, was in his fiftieth year. He was born at Llandaff and commenced his business career with Messrs. Mordey, Carney and Co., after which he went to the Victoria Dry Docks, Swansea. He later returned to the Cardiff district as manager of the Barry branch of the Cardiff Channel Company, and subsequently became general manager of the Barry graving dock and engineering concern on the death of Mr. Robert Monroe. In 1922, when the general managership of the whole of the Cardiff Channel Company's undertakings became vacant, Mr. Cox secured the appointment, he being regarded as a man of exceptional ability and enterprise. He was hon. secretary of the Bristol Channel Engineers' and Ship-repairers Employers' Association, an ex-president of the Dry Dock Owners' and Ship-repairers' Federation, and a member of the Institution of Naval Architects.

Current Business.

Operations on the coal market have been at a very low ebb, owing to the holidays, and it will be next week before settled conditions will prevail. It is expected, however, that the tone of the market will continue to be quiet, and that values will exhibit irregularity, owing to the difficulties of collieries getting the quick clearance of their standing supplies of coal. At the moment prices are little more than nominal.

CATALOGUES.

JAMES GORDON AND CO., Limited, Windsor House, Kingsway, W.C. 2.—Booklet on the Rheograph water flow recorder.

STOTHERT AND PITT, Limited, Bath.—Sectionalised catalogue dealing with electric cranes, steam cranes, and belt conveyors.

CURCHIN AND WATSON, 59, Mark-lane, E.C. 3.—Brochure on the Curchin-Endert one man hand-operated punching table.

J. W. BROOKE AND CO., Limited, Adrian Works, Lowestoft.—Leaflet describing the Brooke two-cylinder 14 horse-power motor.

W. HEFFER AND SONS, Limited, 4, Petty-court, Cambridge.—Catalogue No. 248 of Scientific Books and Publications of Learned Societies.

THE GENERAL ELECTRIC COMPANY, Limited, Magnet House, Kingsway, W.C. 2.—Leaflet No. 3 on "Power Houses and Substations Installations."

GUEST'S BRASS STAMPING COMPANY, Cardigan Works, Belmont-row, Birmingham.—Leaflet on hot die pressings in brass, copper and yellow metal.

MACREADY'S METAL COMPANY, Limited, 7, Baron-street, N. 1.—Price list and leaflet of "Usaspead" bright cold drawn steel and price lists of other products.

BENTLEY AND DRAPER, Limited, 4, Fenchurch-avenue, E.C. 3.—Brochure illustrating and describing the "B and D" stabiliser for motor cars and motor cycles.

UNITED WATER SOFTENERS, Limited, Imperial House, Kingsway, W.C. 2.—Illustrated book on the purification and softening of water by the Permutit system.

RICHARD C. GIBBINS AND CO., Berkley-street, Birmingham.—Catalogue H, containing descriptions of all types of lifting machinery and contractors' tools.

SCOTT AND HODGSON, Limited, Guide Bridge, near Manchester.—Brochure illustrating and describing the "Roth" turbine, entitled "Small Steam Turbines."

THOMAS HOWSE, Limited, Union Works, Smethwick, Staffs.—Cover enclosing eighteen leaflets on various exposure tests for different paints, varnishes and enamels.

ADAM HILGER, Limited, 75a, Camden-road, N.W. 1.—Booklet entitled "Spectrum Analysis with Hilger Instruments" and leaflet on the L. 14 Spectrum comparator.

HENRY WELLS OIL COMPANY, 11, Haymarket, S.W. 1.—Blue print entitled "Lubrication Progress Chart No. 1," comparing "Germ" process oil with other oils.

ATELIERS DE CONSTRUCTIONS ELECTRIQUES DE CHARLEROI, 56, Victoria-street, S.W. 1.—Special publication No. 950, illustrating the A.C.E.C. 1000-kilowatt La Cour motor converter.

THE ANDERSON-GRICE COMPANY, Limited, Taymouth Engineering Works, Carnoustie, Scotland.—Catalogue P.S. 4, illustrating and describing "Anderson" stone and marble working machinery.

WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, Limited, 82, York-road, King's Cross, N. 1.—Catalogue, Section S 11, on the "Power Operation of Points and Signals by Hand Generator."

VICKERS AND INTERNATIONAL COMBUSTION ENGINEERING, Limited, Africa House, Kingsway, W.C. 2.—Catalogue No. 6 on the Raymond pulveriser; No. 7 on pulverised fuel for cement plant; No. 8 entitled the "Statements of Prominent Engineers Regarding Pulverised Fuel."

ENGLISH ELECTRIC COMPANY, Limited, Queen's House, Kingsway, W.C. 2.—Publication No. 453 on "Oil Immersed Circuit-breakers"; technical guide 2110 on "Ironclad Oil Circuit Breaker Pillars;" and publication No. 573 on "Steam Extraction or Pass-out Steam Turbines," part of which appeared in THE ENGINEER of December 19th, 1924.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

ROBERT BOYLE AND SON ask us to announce that their address, No. "64," Holborn-viaduct, has been changed by the London County Council to No. "65."

COX AND DANKS, Ltd., of Ulster Chambers, 168, Regent-street, London, W. 1, ask us to announce that they have severed their connection with Richard Green, Ltd., of Cradley Heath, which had for some time acted as their Midland representative.

WE are informed that Mr. James Hatton, A.M.I. Mech. E., has been appointed to the board of Sutcliffe Bros. and Bryce, Ltd., of Hyde. He will take charge of the company's cold storage insulation department, a branch of insulation in which he has been well known for many years.

WE are informed that W. M. Still and Sons, Ltd., have purchased from Mr. G. C. Johnston, as liquidator, the goodwill and stocks of Blanchard Lamps (British), Ltd., with the object of continuing on their premises at 29/31, Charles-street, Hatton-garden, E.C. 1, as from April 1st, the business formerly carried on by Messrs. Blanchards.

THOS. W. WARD, Ltd., of Sheffield, informs us that it has decided not to dismantle the works and disperse the plant of George Cooper and Sons, Ltd., Effingham Nut and Bolt Works, which it recently purchased. In view of the urgent need for employment and with a desire to continue an old-established Sheffield firm, the purchaser has determined to reorganise and carry on the business under the name of George Cooper and Sons.

CONTRACTS.

JOHN HANDS AND SONS, Ltd., of Birmingham, have received orders from the India Office for large-size high-speed guillotine shears of the overhead crank type, and other work, and a number of other orders for presses for shipment abroad.

HOWDEN-LJUNGSTROM PREHEATERS (LAND), Ltd., have received an order to supply one large preheater to Hurst, Nelson and Co., Ltd., Motherwell. The total heating surface of the preheater is to be 26,700 square feet, and air will be supplied to the furnace at about 315 deg. Fah.

THE VICKERS-SPEARING BOILER COMPANY, Ltd., of Bank Buildings, 20, Kingsway, London, W.C. 2, has received a contract from the Thames Board Mills, Ltd., for four "Spearing" steel-cased cross type header boilers for its Purfleet mill. Two of the boilers will have a normal evaporation of 60,000 lb. per hour and two a normal evaporation of 40,000 lb. per hour, at a working pressure of 350 lb. per square inch. The boilers will be equipped with superheaters of the integral type, with four "Illinois" forced draught type "G" chain-grate stokers, one per boiler. The contract also includes superimposed economisers, coal and ash-handling plant, bunkers, feed pumps, &c.

THE MIRRLEES WATSON COMPANY, Ltd., of Glasgow, has recently received the following orders:—For two evaporators for Dalmarnock power station, Glasgow, each to supply 5700 lb. make-up feed water per hour, and also for two evaporators for Carlisle Corporation, each to supply 6500 lb. of make-up feed water per hour; for one 5in. bore-hole pump to deliver 20,000 gallons per hour, driven directly by vertical electric motor; for one 7in. bore-hole pump, driven directly by vertical electric motor, to deliver 36,000 gallons per hour; for one 5in. bore-hole pump, to deliver 18,000 gallons per hour; and for three 12in. centrifugal pumps for Wigan Corporation Pemberton sewage pumping station, each pump to deliver 3000 gallons per minute against a total head of 40ft., and to run at 720 revolutions per minute.

THE HUXLEY LECTURE.—The Royal College of Science Association has arranged that a "Huxley Lecture" be delivered on Monday, May 4th, at 5 p.m., in the Chemical Lecture Theatre of the old Royal College of Science in Exhibition-road, South Kensington. The lecture will be entitled "Thomas Henry Huxley" and will be delivered by Professor E. B. Poulton, F.R.S. (Hope Professor of Zoology, Oxford). The Governing Body has arranged, in connection with the "Huxley Centenary Celebrations," for a Zoological Exhibition to be held from 3 p.m. to 6 p.m.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Monday afternoon, April 6th, Sir James Crichton-Browne, treasurer and vice-president, in the chair. The special thanks of the members were returned to Sir Humphry Davy Rolleston for his valuable gift of a large number of letters from Sir Humphry Davy. The chairman reported that he had received a legacy of £250, free of duty, with interest for six months, from the late Mr. Kenneth Phipson Hawksley. Dr. A. Barr, Mr. J. Bragg, Mrs. Eckstein, Mr. W. H. Goodman, Miss E. L. Lawson and Mr. Simonis were elected members.

IRON AND STEEL INSTITUTE.—The annual meeting of the Iron and Steel Institute will be held in Birmingham on Wednesday, Thursday and Friday, September 9th, 10th and 11th. A provisional programme of arrangements has been drawn up by the local Reception Committee, of which Mr. George Hatton, Member of Council, is chairman, and Professor T. Turner, Member of Council, vice-chairman. These arrangements comprise the usual business sessions of the Institute for the reading and discussion of papers, a reception by the Lord Mayor of Birmingham, a reception at the University of Birmingham, a luncheon, at which the visiting members will be entertained by the Reception Committee, visits to numerous works in Birmingham and the adjoining district, and an all-day excursion on Friday, September 11th, to Kenilworth, Warwick Castle and Stratford-on-Avon.

FARADAY HOUSE ENTRANCE SCHOLARSHIPS.—As a result of the entrance scholarship examination held at Faraday House Electrical Engineering College on April 7th, 8th, and 9th, the following awards have been made:—R. J. Hiller, Taunton School, the "Faraday" Scholarship of fifty guineas per annum tenable for two years in college and one year in works; M. S. Hawker, Radley College, the "Maxwell" Scholarship of fifty guineas per annum, tenable for one year in college and one year in works; R. P. Horlock, Erith County School, an Exhibition of thirty guineas per annum, tenable for one year in college and one year in works; E. J. R. Kay, Aldenham School, an Exhibition of thirty guineas per annum, tenable for one year in college and one year in works; R. B. Barton, Lancing College, an Exhibition of twenty guineas per annum, tenable for one year in college and one year in works; and J. E. W. Ginger, Watford Grammar School, an Entrance Prize of twenty guineas.

PARADE OF COMMERCIAL MOTOR VEHICLES.—The nineteenth annual parade of the Commercial Motor Users' Association was held in Lincoln's Inn-fields on Saturday, the 4th instant, when some 150 petrol, steam and electric vehicles were entered, in teams of three, owned by many of the largest and most experienced users of motor transport. After every vehicle had been carefully scrutinised by an expert tribunal of judges the *Commercial Motor* Cup and First Prizes were awarded to the team of three Thornycroft lorries entered by Shell-Mex, Ltd. The drivers of the winning vehicles were awarded the Shrapnell-Smith Challenge Cup in addition to their individual prizes and souvenir medals. This is the fourth successive win of the first award by Thornycroft motor vehicles at the C.M.U.A. London parade, the *Commercial Motor* Cup having been won in 1922–3–4 by teams of Thornycrofts owned and entered by Wethered and Co., Ltd., brewers, of Marlow. The success last year secured for that firm the cup outright, and it stood down this year to give other entrants a chance. Shell-Mex, Ltd., had several times been classed second to Messrs. Wethered's winning teams in this parade.

ESQUIMALT DRY DOCK.—When completed, the dry dock now being built at Esquimalt Harbour, Victoria, B.C., will have cost approximately 6,000,000 dollars. It will measure 1150ft. long, 149ft. wide at the top and 126ft. at the bottom. The depth will be 49ft. 6in., with 40ft. of water on sills at high water. The dock will take any ship afloat, or, if desired, can be divided into two sections of 400ft. and 750ft. respectively. It is lined with concrete, with granite coping altars or steps, granite keel and bilge block seats, and is equipped with four caisson berths of granite. Views of the excavating work were given in THE ENGINEER of November 16th, 1923. To make ready for this dock has required the excavation of 81,000 cubic yards of dredging, 41,000 cubic yards of earth excavation, and 350,000 cubic yards of rock excavation; while in the construction of the dock there will be used 103,000 cubic yards of concrete, 105,000 cubic feet of granite, 36,000 lb. of wrought iron, 141,000 lb. of steel, 40,000 lineal feet of piping of various kinds, 1800 tons of cast iron, and approximately 2500 tons of steel will be used on the caissons. There is only one larger dock in the world, says the *Canadian Engineer*, and that is the Commonwealth at Boston, Mass., which is 29ft. longer. The dock will be operated electrically. There will be three 54in. main pumps and two 22in. auxiliary pumps, which will empty the dock in four hours. The water will be pumped out into the sea through a 600ft. tunnel measuring 9ft. by 14ft. When filled, the dock will contain 42,000,000 gallons of water.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	17/6 to 24/-
(1) Spanish	21/-
1) N. African	21/-
N.E. Coast—	
Native	—
Foreign (c.i.f.)	22/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	4 11 6	—
No. 1 Foundry	4 10 6	—
No. 3 Foundry	4 8 0	—
N.E. Coast—		
Hematite Mixed Nos.	4 3 0	4 3 0
No. 1	4 3 6	4 3 6
Cleveland—		
No. 1	4 2 6	4 2 6
Silicious Iron	4 2 6	4 2 6
No. 3 G.M.B.	3 17 6	3 17 6
No. 4 Foundry	3 16 6	3 16 6
No. 4 Forge	3 15 6	3 15 6
Mottled	—	—
White	—	—
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 12 0 to 3 14 0	
,, Forge	3 7 0 to 3 8 0	
(3) Derbyshire—		
No. 3 Foundry	3 17 6 to 3 18 0	
Forge	3 10 0	—
(3) Lincolnshire—		
No. 3 Foundry	4 2 6	—
No. 4 Forge	3 17 6	—
Basic	4 0 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 16 0 (a) / 4 18 6 (b) / 5 5 0 (c)	— / — / —

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	11 12 6	—
Best ,,	—	—
N.E. Coast—		
Common Bars	12 0 0	—
Lancs.—		
Crown Bars	13 0 0	—
Second Quality Bars	12 0 0	—
Hoops	15 0 0	14 15 0
S. Yorks.—		
Crown Bars	13 0 0	—
Best ,,	13 10 0	—
Hoops	14 10 0	—
Midlands—		
Crown Bars	12 15 0	—
Marked Bars (Staffs.)	15 0 0	—
Nut and Bolt Bars	11 15 0	—
Gas Tube Strip	13 0 0 to 13 2 6	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	13 0 0	—
Ship Plates, ¼in. and up	9 10 0	—
Sections	9 5 0	—
Steel Sheets, 3/16in. to ¼in.	11 0 0	—
Sheets (Gal. Cor. 24 B.G.)	—	£17 to £18

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 17 6	—
Angles	8 12 6	—
Boiler Plates	13 0 0	—
Joists	8 12 6	—
Heavy Rails	9 0 0	—
Fish-plates	13 10 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	9 10 0	—
Soft Billets	8 10 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 15 0†	—
Light ,,	9 0 0 to 9 5 0	
Billets	8 0 0 to 11 0 0†	
Manchester—		
Bars (Round)	9 15 0 to 10 0 0	
,, (others)	9 10 0 to 9 15 0	
Hoops (Best)	15 5 0	13 0 0
,, (Soft Steel)	13 15 0	13 10 0
Plates	9 15 0	—
,, (Lancs. Boiler)	13 0 0	—
Sheffield—		
Siemens Acid Billets	11 10 0	—
Bessemer Billets	13 0 0	—
Hard Basic	9 10 0	—
Intermediate Basic	9 0 0	—
Soft Basic	8 0 0 to 8 5 0	
Hoops	12 0 0	—
Soft Wire Rods	9 10 0 to 11 0 0	
Midlands—		
Small Rolled Bars	8 15 0 to 9 15 0	
Billets and Sheet-bars	7 0 0 to 7 10 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	16 10 0	—
Angles	8 15 0 to 9 0 0	
Joists	8 15 0 to 9 0 0	
Tees	9 15 0 to 10 0 0	
Bridge and Tank Plates	9 15 0	—
Boiler Plates	13 10 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	22/1½ to 22/6
Block Tin (cash)	232 0 0
,, (three months)	235 5 0
Copper (cash)	60 7 6
,, (three months)	61 10 0
Spanish Lead (cash)	32 17 6
,, (three months)	31 15 0
Spelter (cash)	34 11 3
,, (three months)	33 11 3
Manchester—	
Copper, Best Selected Ingots	64 15 0
,, Electrolytic	65 15 0
,, Strong Sheets	90 0 0
,, Tubes (Basis Price)	0 1 1
Brass Tubes (Basis price)	0 0 11¾
,, Condenser	0 1 2
Lead, English	35 5 0
,, Foreign	34 0 0

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/9 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 0 0	8/-
,, 6 p.c. to 8 p.c. ,,	£23 10 0	7/9
,, 8 p.c. to 10 p.c. ,,	£23 0 0	7/6
,, Specially Refined		
,, Max. 2 p.c. carbon	£42 10 0	16/-
,, ,, 1 p.c. ,,	£52 0 0	17/-
,, ,, 0.75 p.c. carbon	£58 0 0	19/-
,, ,, carbon free	1/5 per lb.	
Metallic Chromium	4/- per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/- per unit	
,, ,, 75 p.c.	£20 5 0 scale 6/- per unit	
,, Vanadium	17/- per lb	
,, Molybdenum	7/3 per lb.	
,, Titanium (carbon free)	1/- per lb.	
Nickel (per ton)	£175	
Cobalt	10/3 per lb.	
Aluminium (per ton)	£130	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	16/-
,, ,, Ell	17/3
,, ,, Splint	18/3 to 21/3
,, ,, Trebles	14/9
,, ,, Doubles	13/9
,, ,, Singles	13/3
Ayrshire—	
(f.o.b. Ports)—Steam	16/-
,, ,, Splints	18 3
,, ,, Trebles	14/9
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	13/10½ to 16/-
Screened Navigation	22/-
Trebles	15/- to 15/9
Doubles	14/-
Singles	13/3
Lothians—	
(f.o.b. Leith)—Best Steam	16/-
Secondary Steam	15/3
Trebles	16/-
Doubles	14/3
Singles	13/6

ENGLAND.

(8) N.W. Coast—	
Steams	28/-
Household	45/- to 58/4
Coke	28/6
Northumberland—	
Best Steams	16/9 to 17/6
Second Steams	16/6
Steam Smalls	11/-
Unscreened	15/6 to 16/6
Household	23/6 to 25/-
Durham—	
Best Gas	19/6 to 20/-
Second	17/- to 17/6
Household	23/6 to 25/-
Foundry Coke	21/6 to 22/6
Sheffield—	Inland.
Best Hand-picked Branch	30/- to 33/- —
Barnsley Best Silkstone	26/- to 28/- —
Derbyshire Best Brights	28/- to 31/- —
,, ,, House	24/- to 26/- —
,, ,, Large Nuts	20/- to 24/- —
,, ,, Small	14/- to 16/- —
Yorkshire Hards	18/- to 22/- —
Derbyshire ,,	18/6 to 22/- —
Rough Slacks	10/- to 12/6 —
Nutty ,,	8/6 to 10/- —
Smalls	4/- to 6/6 —
Blast-furnace Coke (Inland)*	— —
,, ,, (Export) f.o.b.	21/3 to 22/3

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	26/- to 26/6
Second ,, ,,	25/- to 26/-
Best Dry Large	25/- to 25/6
Ordinary Dry Large	23/6 to 24/6
Best Black Vein Large	24/- to 24/6
Western Valley ,,	23/- to 24/-
Best Eastern Valley Large	23/- to 24/-
Ordinary ,, ,,	22/6 to 23/-
Best Steam Smalls	15/6 to 16/3
Ordinary ,,	13/- to 15/-
Washed Nuts	20/- to 28/-
No. 3 Rhondda Large	27/- to 27/6
,, ,, Smalls	17/- to 18/-
No. 2 ,, Large	22/- to 22/6
,, ,, Through	18/- to 20/-
,, ,, Smalls	12/- to 13/6
Foundry Coke (export)	40/- to 47/6
Furnace Coke (export)	25/- to 30/-
Patent Fuel	23/- to 26/3
Pitwood (ex ship)	24/- to 24/6
Swansea—	
Anthracite Coals:	
Best Big Vein Large	44/- to 46/-
Seconds	38/- to 40/-
Red Vein	29/- to 32/-
Machine-made Cobbles	50/- to 55/-
Nuts	50/- to 55/-
Beans	42/6 to 45/-
Peas	21/- to 23/6
Breaker Duff	9/3 to 9/6
Rubbly Culm	11/6 to 12/-
Steam Coals:	
Large	22/- to 24/-
Seconds	21/- to 22/-
Smalls	10/- to 13/-
Cargo Through	16/- to 19/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 16/9, with fluctuations according to analysis; open market, 18/- to 19/- at ovens. † Latest quotations available. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

Trade Burdens.

It would hardly be possible to exaggerate the feeling of relief with which the industrial and commercial communities have witnessed the fall of the Socialist Government, the financial proposals of which, aimed mainly at capital and industry, are regarded as being primarily responsible for the precarious conditions under which industry is now being carried on. Whether a change in the financial and economical policy will revive confidence cannot be foretold until something is known of the measures which the new Government will adopt to save the country from an apparently inextricable situation. Nothing is needed but confidence to ensure a recovery from the industrial stagnation, but the financial problems are of so serious a character that heavy burdens will necessarily have to be imposed upon the country, and if the burdens are uniformly distributed, instead of being limited to capitalists and producers, there will be some hope that business will revive. It is only by encouraging industrial activity that financial stability can be assured. The burdens will have the effect of increasing standing charges and prime costs and the values of everything are therefore likely to advance still further. This would be less marked than if the present state of things were allowed to continue, when an inevitable collapse of the franc would provoke a disaster from which the country could hardly hope to recover. For the moment there is very little buying in any department of trade. As the mills and forges have limited their production to only a small extent it is probable that stocks are accumulating, and tempting offers are certainly being made for export.

Seamen's Hours.

The new decree imposing an eight hours' day in the merchant marine has now come into operation, but it is very doubtful whether it will be applied with more success than the original measure, which, after two years' vain efforts to get it enforced, had to be modified by a decree recognising a presence of twelve hours as equivalent to eight hours' work. As a means of allaying the apprehensions of seamen a promise was made that the eight hours' working day would be restored as soon as it was adopted in other marines, but now it is seen that all idea of an eight hours' working day on board ship has been finally rejected by foreign countries, the Government has not hesitated to give in fully to the seamen's demands. It has even given more than the seamen claimed, for in a general way the principle of a twelve hours' presence was working quite satisfactorily, and it was only occasionally that trouble was experienced with the seamen's unions. The Government promised to make any losses good to shipowners by granting them subsidies to an amount not exceeding 20 million francs during the present year, which sum is to be taken out of the funds raised by taxes on passengers and seaborne goods for the creation of a Crédit Maritime, or, in other words, a fund that is to be employed mainly to subsidise shipbuilding. The scheme is attacked by the shipowners, who declare that the decree is illegal, and by the Chambers of Commerce at the ports, which affirm that the proposed taxation would deal a heavy blow at the French shipping industry. The Bill to authorise the creation of the Crédit Maritime has not passed through the Senate, nor is it likely to in view of the political change, and the downfall of the Government may even have the effect of causing a repeal of the eight hours' decree.

Coal Production.

The French market for British coal has been so largely restricted through the change which has taken place in the economical conditions that a recovery of the business is only possible by further developments, notably by an appreciation of the franc. The consequences of the new economical conditions are clearly set forth in the annual report of the Comité Central des Houillères, in which it is stated that, following upon the reconstruction of the colliery equipments in the devastated areas, and upon the employment of coal cutting machinery wherever possible, the production increased from 22,500,000 tons in 1919 to 45,000,000 tons in 1924, and the present monthly output promises a total for the present year of more than 48 million tons. Excluding the contribution of the Lorraine collieries, the French production has already reached, and even exceeded, the pre-war level. While in 1913 the number of miners was 203,000, it had increased at the beginning of the present year to 311,000, largely from foreign sources, but the individual production has fallen by more than 18 per cent., despite the use of labour-saving machinery. The smaller output per man is attributed to the eight hours' day. The coal consumption in France increased last year to 75 million tons. The Saar collieries, which are worked for the French State, supplied France with 5,214,000 tons and the coal imports from Germany amounted to 4,265,000 tons. The imports of Belgian coal fell to 1,710,000 tons, while the consignments of British coal dropped from 18 million tons in 1923 to 13 million tons. The declension in the purchases of British coal was therefore due mainly to the heavy consignments from the Saar and from Germany. So far as the Saar is concerned the supplies will continue, and may increase, for another ten years, when it will be decided whether the coalfield will remain under French jurisdiction or will return to Germany. It does not seem likely that German coalowners will compete keenly for the French trade, as they have always been in arrears with the supplies on account of reparations, but the reparation coal and the restoration of the Lorraine coalfield, together with the Saar, have considerably narrowed down the market formerly supplied by British coalowners. The increasing use of pulverised native fuel for steam raising is also helping to reduce imports. Nevertheless, there is a sufficiently large margin between coal output and consumption to warrant the hope that Great Britain will recover lost ground in this country as soon as there is an appreciable improvement in French currency values. The Comité Central des Houillères points even to the possibility of severe competition from British coal in the event of such an appreciation wiping out the comparatively small margin of price in favour of French coal.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

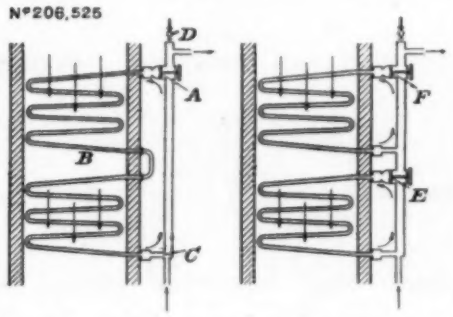
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

206,525. November 6th, 1923.—Improvements in or relating to Feed-water Heaters of the Economiser Type, Max and Ernst Hartmann, of Freital-Deuben, near Dresden, Germany.

The economiser type of feed-water heater described in this specification is provided with a pump A which circulates the water in the pipe system B in order to ensure that no great rise of temperature takes place, thus preventing any appreciable

N° 206,525

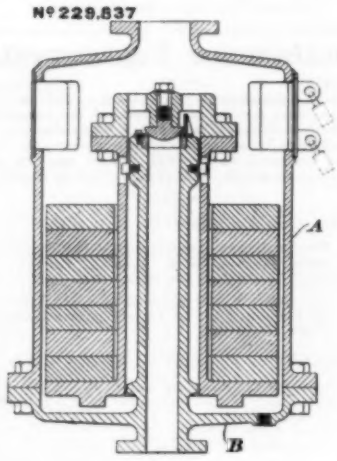


separation of gases from the water. At the junction C the circulating water mixes with the water to be warmed. The gases which are liberated during the mixing process are carried along within the water until they reach the surface, and escape through the exhaust pipe D. At the point D the same quantity of water that entered at C leaves the economiser. The warming can be carried out in steps, as shown in the right-hand drawing, in which two circulating pumps E and F are shown.—*March 5th*, 1925.

229,837. January 26th, 1924.—Improvements in Safety Valves, Robert Arnold Blakeborough and Colonel John Vickers, both of Woodhouse Works, Brighouse, Yorks.

Safety valves of the type in which the load is applied by deadweights are liable to be tampered with by unauthorised persons, and one of the objects of this invention is to remove this objection. Another object is to provide a better outlet than usual for the escaping steam. The casing A, which encloses the deadweights, is in the form of a dome or cylinder closed at its upper end, with the exception of a central discharge outlet, and bolted at its lower end to a flange B on a central inlet pipe. On the upper end of the pipe is a valve, which is carried by a removable

N° 229,837



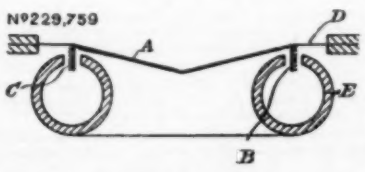
cap member secured to a sleeve surrounding the inlet pipe and carrying the deadweights. The cover or casing is provided with an aperture, so disposed as to permit of the withdrawal of the cap member and valve when the cap has been removed from the sleeve, means being provided to close the aperture or apertures against unauthorised access. The lower end of the sleeve is so arranged with respect to the flange on the inlet pipe that the latter, when the cap member is being removed from the sleeve, takes the weight of and supports the sleeve and deadweights before the bolts by which the cap member is secured become detached. Means are also provided to limit the movement of the sleeve carrying the valve stopper and the deadweights.—*March 5th*, 1925.

TELEGRAPHS AND TELEPHONES.

229,759. November 29th, 1923.—Improvements in Receiving and Transmitting Telephones, including Loud Speakers, Henry Joseph Round, of 9, Woodbury-crescent, Muswell Hill, London.

Round the edges of a stiff diaphragm A there is a flange B,

N° 229,759



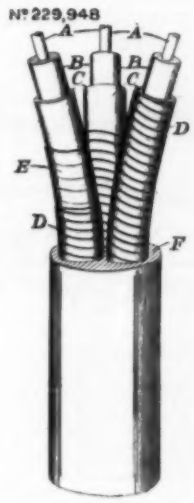
which carries a coil C. The diaphragm is supported by a thin rubber ring D in such a position that the coil C is suspended in the annular air gap of a magnet E, in the form of a torus, containing within it a magnetising winding, which is not shown. When speech currents are passed through the coil the diaphragm is moved as a whole, and produces sound waves, whilst when sound waves fall upon the diaphragm they will move it, and corresponding currents will be produced in the coil. Several similar arrangements are illustrated.—*March 2nd*, 1925.

TRANSMISSION OF POWER.

229,948. September 2nd, 1924.—Improvements in or relating to Multicore Electric Cables, W. T. Henley's Telegraph Company, Ld., of 13 and 14, Blomfield-street, London-wall, E.C. 2, and Percy Dunsheath, of Henley's Telegraph Works, Ld., North Woolwich.

The cable described in this specification comprises three conductive cores A, each insulated in the usual manner as at B, the

N° 229,948



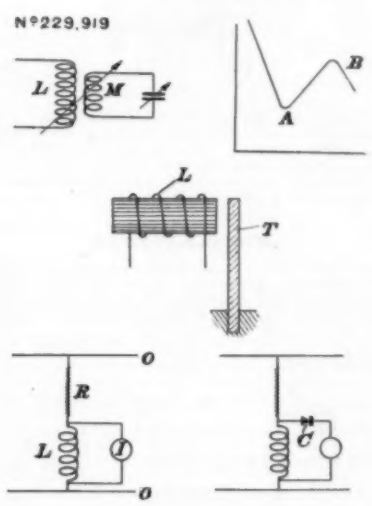
insulation being enclosed in a lead sheating C. Each insulated and sheathed core is tightly whipped with metallic or other tape D, having a relatively high tensile strength, there being interposed, if desired, between the lead sheath C and the tape whipping D a lapping of paper like E applied prior to the whipping. The three insulated and whipped cores are laid up together and surrounded by a common protective covering of insulating or other material, as indicated at F.—*March 5th*, 1925.

MEASURING AND TESTING INSTRUMENTS.

229,919. June 13th, 1924.—Improvements in and relating to the Measurement of Frequency of Electric Circuits, Edward Mallett, of 31, Engayne-gardens, Upminster.

The inventor's scheme for measuring frequency is applicable to high and low frequencies. Referring to the top left-hand diagram, if a voltage V of constant amplitude but variable frequency be applied to the coil L, then if Z is the impedance of the coil, a current of magnitude V/Z will flow through the coil, and as the frequency is increased so the impedance of the coil will increase and the current will decrease. If now an oscillatory or vibratory circuit M be coupled to the coil L, the impedance of the latter will be affected. As the frequency is increased through the resonance frequency of the circuit M, the impedance of the coil L will first increase, then rapidly decrease, and finally increase again to a value approaching that which it would have possessed had the second circuit M been absent. The corresponding current changes are shown in the curve on the right of the diagram. By making the inductance and capacity of the circuit M variable, this second circuit can be adjusted

N° 229,919



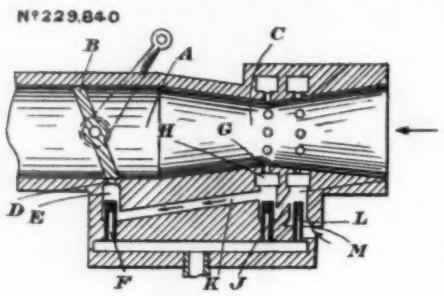
to resonate at any desired frequency. An ammeter in circuit with the coil L will indicate deviations in the frequency of the current under examination. Similar changes will take place in the current and impedance of the circuit if the circuit M be replaced by a mechanical vibrating device, such as a tuning fork. The steepness of the curve from A to B depends upon the damping of the oscillatory circuit or vibrating device. The middle illustration shows a mechanical vibrating device which might be used, where L is the coil and T a tuning fork. The alteration in impedance produced in the coil L or in a corresponding inductive member by variations in frequency might be measured by determining the changes in current flowing through the coil. An alternative scheme is shown in the lower left-hand diagram, where R is a high resistance and L the inductance. These are connected in series across mains O, the frequency of which it is desired to determine. The amount of current flowing through L will be governed chiefly by the value of R, and will be approximately constant, but the potential across L will vary

with its effective impedance, which, in turn, depends on the frequency. The potential is measured by an alternating current voltmeter or a direct-current instrument, if a crystal C is used, as shown in the right-hand bottom diagram.—*March 5th*, 1925.

MOTOR CARS AND ROAD TRAFFIC

229,840. January 31st, 1924.—Improvements in Carburetters, A.M.A.C., Ld., and William Leslie Guy, both of Lion Works, near Witton Station, Birmingham.

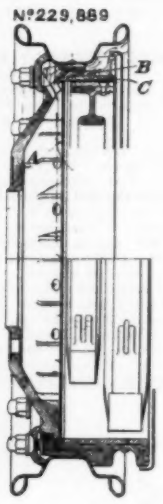
The carburetter described in this specification has a horizontal air passage A and a butterfly valve B. The passage has a restriction C for a choke tube, and the throttle valve turns about a horizontal axis. The passage D is covered by the edge of the throttle when the latter is closed, and it forms the outlet of a choke tube E for a main pilot nozzle F. At the throat of the main air restriction C is another outlet G for a choke H, in which the main nozzle J is placed. These choke tubes may be con-



stituted by recesses in the wall of the main passage. At the lower end of each choke tube E and H is an aperture, through which the tip of a nozzle projects into the choke tube. A passage K connects the two choke tubes E and H, and preferably the end towards the pilot nozzle F is below the outlet of the latter. Although the desired effect can be obtained from the nozzles F and J only, it is preferable to add an additional nozzle L adapted to come into operation at maximum throttle openings. The space M is for the entrance of air. The action of this carburetter is fully described, and an alternative arrangement is dealt with.—*March 5th*, 1925.

229,889. April 5th, 1924.—Improvements relating to Vehicle Wheels, The Lanchester Motor Company, Ld., and George Herbert Lanchester, all of Armourer Mills, Montgomery-street, Birmingham.

A motor wheel constructed in accordance with this invention reduces the transmission of heat from the brake surface to the

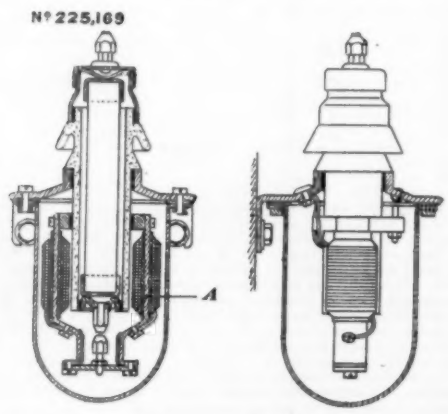


tire to a minimum. The web A is provided with an overhanging flange B and the inner surface of the flange serves as a brake surface, with a lining C. The wheel is constructed so that air circulates through passages as indicated by the arrows, and prevents an undue communication of heat from the brake surface to the rim carrying the tire.—*March 5th*, 1925.

MISCELLANEOUS.

225,169. June 18th, 1924.—Improvements in or relating to Lightning Arresters, Schiele und Bruchsaler Industriekonzern, of 2, Guattigstrasse, Baden-Baden, Germany.

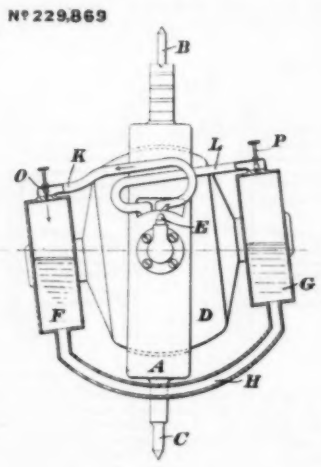
This invention relates to an enclosed lightning arrester with



magnetically extinguished spark and non-inductive resistance of the kind in which one electrode, of "silit" or similar material, is mounted in a lead-through insulator. The spark-extinguishing magnet and the counter-electrode are likewise fitted to the insulator, for the purpose of rendering the length of the spark gap unaffected by any possible distortion of the casing. The length of the spark gap always remains unaltered. A non-inductive resistance parallel to the coil as used hitherto is dispensed with, as it has been found that it lowers the spark-extinguishing effects and increases the cost of the apparatus.—*February 26th*, 1925.

229,869. March 12th, 1924.—Improvements in or relating to Gyro Compasses, Sydney George Brown, of Victoria-road, North Acton, London.

This specification describes a gyro-compass in which north-seeking is effected by the gravitional flow of liquid in a pair of bottles. The vertical ring is indicated at A, the pivots enabling it to turn about a vertical axis B C. Within the vertical ring, the gyro-casing D is pivoted to turn about an axis at right angles to the plane of the paper, the gyro-casing pivots to permit this movement being in the form of hollow trunnions to allow compressed air from within the casing to pass to the nozzle E. Within the gyro-casing, the gyroscope itself—not shown—is rotated in any suitable manner. Attached to the gyro-casing is a pair of bottles F G, containing mercury, the bottles being



connected below by a tube H of restricted cross-section, which, if necessary, can be made adjustable. Pipes K L are connected respectively to the upper parts of the bottles, and they cross one another so that their open ends are disposed as shown in relation to the air nozzle E. Control of the flow of air into the bottles through the pipes is effected by means of the needle valves O P. As the gyro-casing tilts, mercury flows down under gravity to the lower bottle, thereby giving the sensitive element an arc-in-azimuth or north-seeking movement, while damping is effected by an extraneous source of power, viz., the pressure air in the example described acting on the surface of the mercury in the bottles, the necessary lag or phase difference for this purpose being effected by adjustment of the valves O P.—*March 5th*, 1925.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Diesel Engine Users' Association.—The Engineers' Club, Coventry-street, London. W. 1. Paper, "Recent Oil-engine Developments," by Mr. J. L. Chaloner. 3.30 p.m.

Junior Institution of Engineers.—39, Victoria-street, Westminster, London, S.W. 1. Paper, "Vertical Retorts," by Mr. W. T. Dunn. 7.30 p.m.

TO-DAY AND SATURDAY, APRIL 18TH.

Model Railway Club.—Kingsway Hall, Kingsway, London, W.C. 2. Exhibition of members' work, &c. To-day, 2 p.m.: Saturday, 10 a.m.

SATURDAY, APRIL 18TH.

Institute of British Foundrymen: Lancashire Branch, Junior Section.—College of Technology, Manchester. Lecture on "Foundry Materials," by Mr. A. Hill. 7 p.m.

Institution of Municipal and County Engineers.—Town Hall, Wakefield. Yorkshire District quarterly meeting. Discussion on "Building By-laws," introduced by Mr. A. Rothera. 2.30 p.m.

MONDAY, APRIL 20TH.

Institution of Automobile Engineers: Birmingham Centre.—Chamber of Commerce, New-street, Birmingham. Paper, "Brakes for Motor Vehicles," by Mr. G. W. Watson. 7 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. Howard Lecture, "Motor Fuels—I.," by Professor John S. S. Brame. 8 p.m.

MONDAY TO WEDNESDAY, APRIL 20TH TO 22ND.

Royal Microscopical Society.—Conference at Sheffield. For programme, see page 390.

TUESDAY, APRIL 21ST.

Institution of Automobile Engineers.—The Broadgate Café, Coventry. Coventry Graduates' meeting. Paper, "Designing Rear Axles for Production," by Mr. C. Burrows. 7.15 p.m.

Institution of Civil Engineers.—Great George-street, Westminster, London, S.W. 1. Paper, "The Johore Causeway," by Mr. Donald Paterson. 6 p.m.

Institution of Electrical Engineers: North Midland Students' Section.—The University, Leeds. Address by the chairman, Mr. T. B. Johnson. 7 p.m.

Institution of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow. Annual general meeting Paper, "Aerodynamics of the Rotating Cylinder," by Mr. Alexander Thom. 7.30 p.m.

Manchester Geological and Mining Society.—Queen's Chambers, 5, John Dalton-street, Manchester. Paper, "The Principles and Operation of the Mines (Working Facilities and Support) Act, 1923, Part I.," by Mr. J. H. Cockburn. 4 p.m.

Newcomen Society.—University College, Gower-street, London, W. 1. Papers, "Glass-making in Egypt," by Sir Flinders Petrie; "Chiddingfold Glass and its Makers in the Middle Ages," by Mrs. Brenda C. Halahan; "The Interrelationship of the Glassmakers in Western Europe," and "Glass-making under the Roman Empire," by Mr. E. W. Hulme. 5 p.m.

WEDNESDAY, APRIL 22ND.

Institution of Automobile Engineers: North of England Centre.—Milton Hall, 244, Deansgate, Manchester. Paper, "Brakes for Motor Vehicles," by Mr. G. W. Watson. 6.30 p.m.

Institution of Chemical Engineers.—Chemical Society's Rooms, Burlington House, Piccadilly, London, W. 1. Paper. "Continuous Distillation of Petroleum," by Mr. A. M. O'Brien. 8 p.m.

Institution of Civil Engineers.—Great George-street, Westminster, London, S.W. 1. Annual general meeting of the Association of London Students. 6 p.m.

Institution of Electrical Engineers: North Midland Students' Section.—Visit to the works of the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester.

Institution of Production Engineers.—The Engineers' Club, Coventry-street, London, W. 1. Paper, "Press Tool Work," by Mr. F. P. Turner. 7.30 p.m.

THURSDAY, APRIL 23RD.

Institution of Automobile Engineers.—Watergate House, Adelphi, London, W.C. 2. London Graduates' meeting. Lecture, "Modern Machine Tool Methods," by Messrs. Buck and Hickman. 7.30 p.m.

Institution of Automobile Engineers.—Training School of Vauxhall Motors, Ld., Luton. Luton Graduates' meeting. Paper, "Supercharging," by Mr. P. H. Goffey. 7.30 p.m.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. "Recent Improvements in the Insulation of Electrical Machinery," by Lieut.-Colonel K. G. Maxwell and Mr. A. Monkhouse. 6 p.m.

Institution of Mining and Metallurgy.—Geological Society's Rooms, Burlington House, Piccadilly, London, W. 1. Annual general meeting. Presidential address by Sir Thomas H. Holland. 5.30 p.m.

Institution of Welding Engineers.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Overheating in Acetylene Generators," by Mr. Charles Bingham. 8 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, London, W. 1. "A Year's Exploration in Tibet," by Mr. F. Kingdon Ward. 5.15 p.m.

FRIDAY, APRIL 24TH.

Institute of Metals: Sheffield Local Section.—Mappin Hall, Department of Applied Science, The University, St. George's-square, Sheffield. Paper, "Chromium Plating," by Mr. Byron Carr. 7.30 p.m.

Institute of Metals: Swansea Local Section.—Metallurgical Department of the University College, Singleton Park, Swansea. Annual general meeting. 7.15 p.m.

Institution of Mechanical Engineers.—Storey's-gate, Westminster, London, S.W. 1. Reports to the Hardness Tests Research Committee. "The Effects of Adhesion between the Indenting Tool and the Material in Ball and Cone Indentation Hardness Tests," by Mr. G. A. Hankins; and "Some Practical Aspects of the Scratch Test for Hardness," by Mr. G. A. Shires. 6 p.m.

North-East Coast Institution of Engineers and Shipbuilders.—Lecture Theatre of the Literary and Philosophical Society, Newcastle-upon-Tyne. "Gas Turbines," by Mr. M. König. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, London, W. 1. Discourse, "The Icelandic Sagas," by Professor W. A. Craigie. 9 p.m.

MONDAY, APRIL 27TH.

Faraday Society.—Chemical Society's Rooms, Burlington House, Piccadilly, London, W. 1. Papers: "Adhesion of Deposited Nickel to the Base Metal," by Mr. A. E. Ollard; "The Brittleness of Zinc-plated Steel," by Mr. H. Sutton; "The Partition of Silver between Lead and Zinc," by Mr. W. A. Naish; "The Elasticity of Gelatin Jellies and its Bearing on their Physical Structure and Chemical Equilibria," by Mr. H. J. Poole; "A Note on the Reduction Potential of Dicyanquinhydrone," by Mr. E. K. Rideal; (i.) "On Some Physical Properties of Water," (ii.) "On the Relation between the Viscosities of Liquids and their Molecular Weight," by Mr. D. B. Macleod. 8 p.m.

Institution of Automobile Engineers: Scottish Centre.—Royal Technical College, Glasgow. Paper, "The Accessibility of the Pleasure Car Chassis," by Mr. M. Platt. 7.30 p.m.

Institution of Mechanical Engineers: Graduates' Section.—Storey's-gate, Westminster, London, S.W. 1. Exhibition of Industrial Kinematograph Films. 7 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. Howard Lecture, "Motor Fuels—II.," by Professor John S. S. Brame. 8 p.m.

TUESDAY, APRIL 28TH.

Institute of Marine Engineers.—85–88, The Minories, Tower-hill, London, E. 1. "Steam Accumulation," by Mr. D. M. Proctor. 6.30 p.m.

Institute of Metals: North-East Coast Local Section.—Electrical Engineering Theatre, Armstrong College, Newcastle-on-Tyne. Annual general meeting. 7.30 p.m.

Institution of Automobile Engineers.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "The Accessibility of the Pleasure Car Chassis," by Mr. M. Platt. 7 p.m.

Institution of Electrical Engineers: North Midland Centre.—Hotel Metropole, King-street, Leeds. Annual general meeting and smoking concert. 6.45 p.m.

THURSDAY, APRIL 30TH.

Institution of Civil Engineers: Birmingham and District Association.—Chamber of Commerce, New-street, Birmingham. Annual general meeting. 6 p.m.

FRIDAY, MAY 1ST.

Faraday House Old Students' Association.—Prince's Hall, Hotel Cecil, London, W.C. 2. Annual smoking concert. 8 p.m.

FRIDAY, MAY 8TH.

Institution of Mechanical Engineers.—Storey's-gate, Westminster, London, S.W. 1. Fourth Report of the Steam Nozzles Research Committee. 6 p.m.